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MINERAL RESOURCES
OF
ARMENIA
AND ANATOLIA

By
HAGOP A. KARAJIAN
METALLURGIST

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To
the memory of
my mother.
Deported and died in Irbid
(Arabian Desert.)

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PREFACE

A glance at the early history of this tramping-ground of our Aryan forefathers gives the impression that the region was both better known and better appreciated by them than by its modern inhabitants. Fully 3,000 years ago, Asia Minor, as a human habitation, was already very old, and there flourished in certain portions of it a civilization as advanced, in many of its phases, as the later Roman culture ever was.

Along with the recognition of the economic value of various ores, mining has assumed such importance as to have become the means of sustenance of numerous settlements scattered from the Aegean coastland to the Persian Gulf. Within that territory, empire after empire had risen to power, and passed into oblivion. Colonies of the vanished kingdoms of Sumner and Akad, preceding the Babylonian Empire itself, has flourished in the fifth millenium B. C. With the westward march of progress, the Hittite power come into being; and finally, the ten centuries immediately preceding the birth of Christ witnessed an unparallalled growth of civilization on the eastern shore of the Aegean Sea. During this period Greek paganism evolved a highly-advanced organized life. In each of these successive stages of culture, the art of working ores was profitalby carried on; the metals being respectively valued according to their relative abundance and usefulness, or commercial importance.

This active mining operations started 2000 years B. C., were carried on pregressively up to the end of the eleventh century A. D., when barbarians of Turkestan invaded the country. Subsequent to this period centuries of corruption and misrule barred the development of the industry.

To prospect on Turkish soil was usually a hazardous undertaking because of the lack of orderly government. The geologist was hindered in his field work; general knowledge of the geology of Turkey was, therefore, fragamentary. No attempts have been made to establish an active geological survey.

Through the pressure exerted by the embassies, foreigners

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have travelled through the provinces under the safeguard of a military escort. It is due to them that we know something regarding the geological and mining features of the region. The country itself has been impoverished to such an extent as to be utterly unable to finance any commercial undertaking whatever. Corrupt officialdom, unfavorable mining laws and the absence of roads, all have been contributed to prevent mining from becoming a prosperous industry. Except at mines situated near the Coast, the necessary machinery for working could not be installed, owing to the transport difficulties. The introduction of electrical machinery has been prohibited, except under very special circumstances, while the admission of explosives has always been a matter of the greatest difficulty and expense. Under these conditions it is not to be wondered at that capitalists have been shy of investing in mining undertakings.

The momentous political change that has recently taken place in Turkey, through the victory of Allied Nations, invites our attention to the mineral resources of the country. Through the annihilation of Turkish terror, a barrier against the civilization and progress, and through the freedom of Armenian element in Turkey, granting them an independent government under the mandate of an advanced nation like America, there cannot be any doubt that a liberal and well dministrted mining law will be established; a strong department of mines with a competent staff of mining engineers, will be formed; capital for developing mineral property will flow into the country to the great advantage of the national finances; the railways, an important factor in the expnsion of mining enterprise will soon develop.

Flourishing industries therefore, are perforce subordinate to the existence of order and peace. Fortunately, there is reason to believe that the nation who will kindly lead us will intend to carry out a broad-minded policy to favor the expansion of mining and its allied industries in our own country. With the adoption of such a course many interesting features of technical practice in these territories will doubtless be revealed within the next decade or so. Most mining engineers are familiar with the admirable results obtained in Mexico, within a comparatively short period of time, nor is the result of push and energy in our own country less striking.

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Comparisons are instructive, at times, and it was futile to belittle the importance of granting due recognition to modern industrial tendencies as exhibited in the practice of the more advanced nations. A study of these features and the causes conductive thereto, may advantageously shape the policy to be adopted by those upon whom the responsibility of developing the country's natural resources has been thrust.

HAGOP A. KARAJIAN.

New York, Jan. 1920.

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INTRODUCTION.

The lack of Aryan roots for the names of metals commonly known among the Aryan settlers of Asia-Minor, as well as the later colonizers of Europe, indicates that these races were generally ignorant of the use of metals until they came in contact with Semetic peoples. Practically all mining terms in current use among the earliest Greeks resemble very strongly their distinctly Semitic equivalents, which can be traced all the way in a broad belt beginning in the Lower Mesopotamia and extending westwardly to the Syrian Shores of the Mediterranean. The Greek work *"Metallon"* for instance, used indiscriminately to designate mine or ore, probably came from the earlier Semitic equivalent, "metal." Or again the Greek words *"Chrysos"* (gold) and *Chalkos"* (copper) seem to be descended from the Semitic forms *"Chrouts"* and *Chalak."* It is a natural inference that primitive mining methods were evolved by the dwellers in the mineralized areas of Asia Minor, from whom later Greeks, Roman and even North European miners obtained their first notions of the reduction of metallic ores, by virtue of a general westward migration of mining and metallurgy.

Anatolia and Armenia have been the seat of active mining operations from about 2000 years B. C. to the end of the eleventh century. Subsequent to this period, centuries corruption and misrule barred the development of industry. With few exceptions, all the remains today, consists of innumerable old workings scattered throughout the country.

An interesting relation between orographic and geological features and the occurences of mineral deposits is observable. The westernmost projection of the Asiatic continent may be likened to a bowl, the rim of which is partly formed by the coastal mountain chains, the rest being completed by the elevated ranges of eastern Armenia. The interior of the bowl is made up of the plateaus which, so far, are not known to be extensively mineralized. At all events, the bulk of the known metallic ore depoists lie in the folds of the marginal uplifts, and the non-metallic minerals lie in the beds of plateau forma-

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tions.

The mining operations carried on so far are all by foreign companies, the capital being supplied from England, France and Germany. Concessions are granted by the government for 99 years, the companies being required to pay 5% royalty, 1% export duty, and a yearly tax of from 40 to 50c per hectare. This was a general rule, although some concessions formerly granted for mining chrome ore and emery for a period of 60 years with a royalty of 10 per cent. Salt was a government monopoly.

The most important ore deposits which are capable of development under expert management and sufficient outlay are summarized as follows:

1. Magnetic iron beds at Ayas-mand, north of Smyrna; limonite iron beds of Bulgar-dagh, Cilician Tanrus; and a rich hematite in Zeitun district, at the foot of the eastern slope of Anti-Taurus (Beiroot-dagh).

2. Chrome ores are widely distributed in Daghardi-Kutahia, in N. W. Anatolia; Makri, on the S. W. coast of Asia Minor; in the neighborhood of Alexandretta, on S. E. Asia Minor, and at Argana-Maden, north of Diarbekir. In peace times the chrome ores of Asia Minor have met the competition of richer ores.

3. Copper ores are widely distributed on Black Sea Coast, especially in the state of Trebizond; Taurus mountains, especially in Palu and Argana at Arghana-Maden, 65 Km. N. W. the principal bed's extension is equivalent to 1.7 to 2 million tons containing 10-11 percent copper. In the west part of the Caucasus (the region Batum-Kars) Khvarzkhana, near Artvin, south of Batum, had a copper mining and smelting works, ready before the war but never operated, belonging to the Siemens family and capable of yielding 2000 tons of copper a year. In the same region an American Company possesses a mining and smelting works at Dzanzul, which produced 3030 tons of copper in 1912 and 4000 tons in 1914, i. e., one third of the whole Caucasus ouput, and one tenth of that of Russia.

4. Occurences of lead and zinc ores are comparatively important and promising, especially Balia Karaidin 40 Km. N. W. of Bali Kesri, N. W. Asia Minor, the property of a Franco-Belgian Company. Output in 1913, 13076 tons of crude lead

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and 5000 tons of zinc. Amount of ore shown by explorations 300,000 to 350,000 tons; farther explorations may show more. Bulghar-Maden, in the Taurus in S. E. Asia Minor, Turkish state property, has some mining so far little developed in the very argentiferous cementation zone. The bed stretches for some 20 Km. in length, and lies only 16 Km. as crow flies from the Baghdad railway.

5. Rock salt is widely distributed but the Calcium borate of Soultan-Chair, 65 Km. south of Panderma, on the Sea of Marmora, is very important as a raw material for metal working, and valuable for glass, enamel, and tanning purposes. The pandermite beds, frequently interrupted, embedded in gypsum and attaining a thickness of 4.5 m. consists of small and large lenticular masses of the milk white mineral. The value of the deposits, which in the most part is the possession of an English Company, is effected by the irregularity of the gypsum and pandermite deposits. Out of the hitherto developed area of 0.859 Km., 281,095 tons pandermite with 45% Borate contant, have been won in the last 27 years. Some 100,000 tons are still available.

6. Coal occurs at Heraclea (Eregli) or Zonguldak, on the south coast of Bleak Sea, in some 22 beds worth working with 40 m. of coal, which has however a great deal of ash and cokes badly. It is worked by a French Company. Amasra, 50 Km. E. Sogut-Oezu and Ooesgeu where the coal is better and cokes better (South of the harbor of Idde) are also on the line of the coal formations, which extend altogether to 170Km. in length. The best lignite is formed at Soma, N. E. of Smyrna, is 15 m. thick, and develops 5200 thermal units; poorer stuff, of local importance only, is to be found at Sivas, in E. Anatolia.

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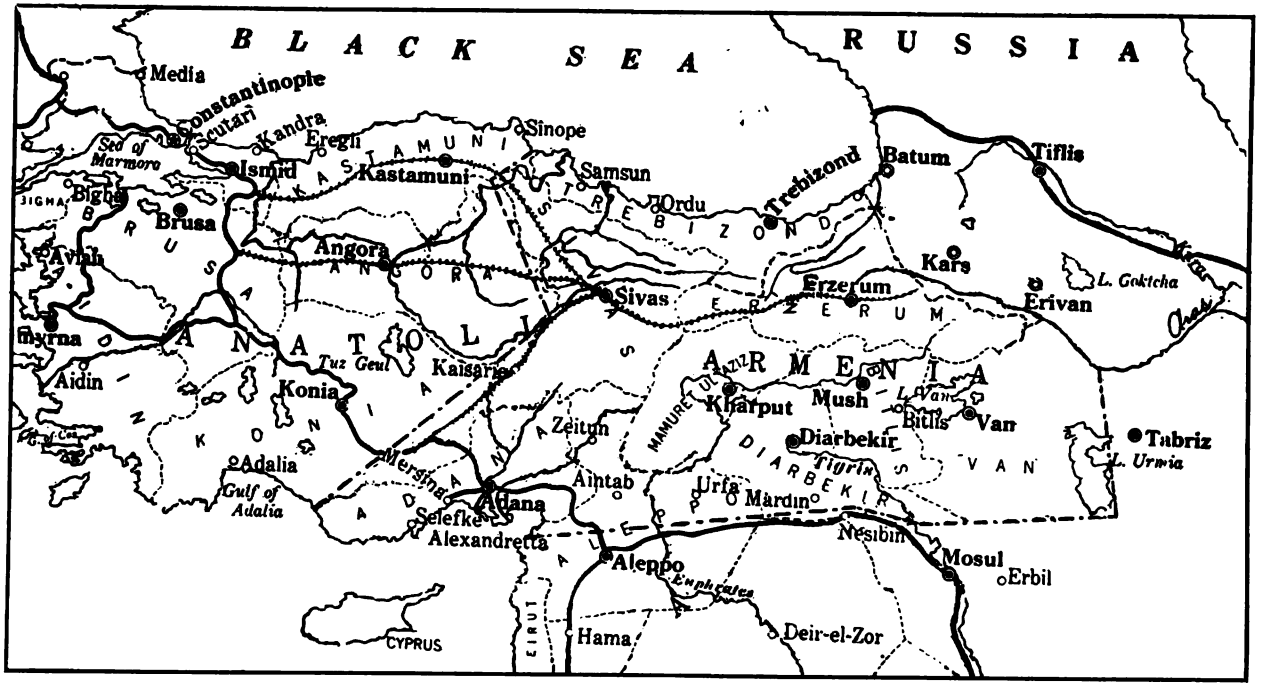

SKETCH MAP OF HISTORICAL ARMENIA INCLUDING THE CILICIA

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PART I.

STRUCTURE AND GEOLOGY

General Structure of Asia.

From the Mediterranean to the Pacific the Asiatic Continent is traversed by a zone of elevated country, which flanked on the north and south by great chains of mountains, breaks off on the west to the Aegean Sea and to the lowlands of China on the east. Extensive areas of land with considerably lesser altitude are outspread on either side of this gigantic system; in the north the plains of Russia and Siberia, in the south the peninsulas of Arabia and India. The mountain chains which confine the zone of elevated country have been reared during different geological periods; yet they are subject to common laws. They are disposed in extensive acrs, of greater or lesser curvature, which are festooned across the continent on either side of the plateau region with a general direction from east to west. The plateau region is in general syclinal or in other words, of slightly hollow surface, and in comparison with the flanking ranges are flat.

Our Globe sails through the wan expanse of ether, diffusing the heat with which it is charged. Cooling crust shrinks and gathers inwards toward the centre; but the material of which it consists is inelastic and is thrown into gigantic wrinkles or folds. Radial contraction induces tengential stresses at the surface, collossal forces which bind over and invert the folds and even thrust the strata one beneath another, causing them to be disposed like the tiles upon a roof. This lateral tension finds most relief where the crust is weakest and it is at such points, or along such zones, that the process of mountain making has been developed on the largest scale. It is the tendency of such folded ranges to form arcs of large curvature, which are drawn inwards where the lateral pressure meets with most resistance, and expand outwards, where it is withstood in a lesser degree.

In Asia the operation of this process of mountain making has been accompanied by, or has proceeded, the elevation in masses

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of large portions of the earth's crust. The intensely folded regions, or in other words, the great chain of mountains, are found along the inner and the outer margins of the elevated mass. Between these zones the stratified rocks have no doubt been subjected to the folding process; yet they have escaped the immense contortions that have taken place on either side.

Throughout the Continent the lateral force which has been most operative in mountain making has proceeded from the north. The fact may perhaps be explained by supposing that this force is the result of the active pressure extended by the hard, unyielding material of which the steppes of Siberia and the basin of the Arctic Ocean are composed. The great arcs which are described, by the mountain ranges are in general convex to the south. Thus in Western Asia the chains on the inner and outer margins of the elevated are disposed on two roughly parallel series of arcs bulging towards the south. Of these series the inner arcs have less curvature than the outer, to which they are roughly parallel.

The inner series may be traced with greatest singleness of feature on the west of Hinda-Kush that natural centre of the mountain systems of Asia, which at once supplies the most conventient standpoint for a general survey of the structure of the contient, and is placed at the junction of the two great divisions, western and eastern, into which geographers have partitioned this vast area. The Hindu-Kush inclines over into the Poropamisus; and the southern portion of the latter range is continued, on the north of Persia, by the mountains of Khorasan. A sharp bend in the belt, just east of the Caspian, turns southwards into the Elburz range, and the beautiful curve of the chain along the margin of the shore may be admired from the waters of that inland sea. The line of Elburz range, and the beautiful curve of the chain along the margin of the shore may be admired from the waters of that inland sea. The line of Elburz range is protracted across the depression of the Araxes Valley into the peaks of Karabagh; while the Karabagh system unites with the bold and lofty ridges which in full face of their gigantic neighbor, the Caucasus overtower the right bank of the Kur. These ridges again connect with the chain between Kutais and Akhaltsykh, a chain which joins the mountains on

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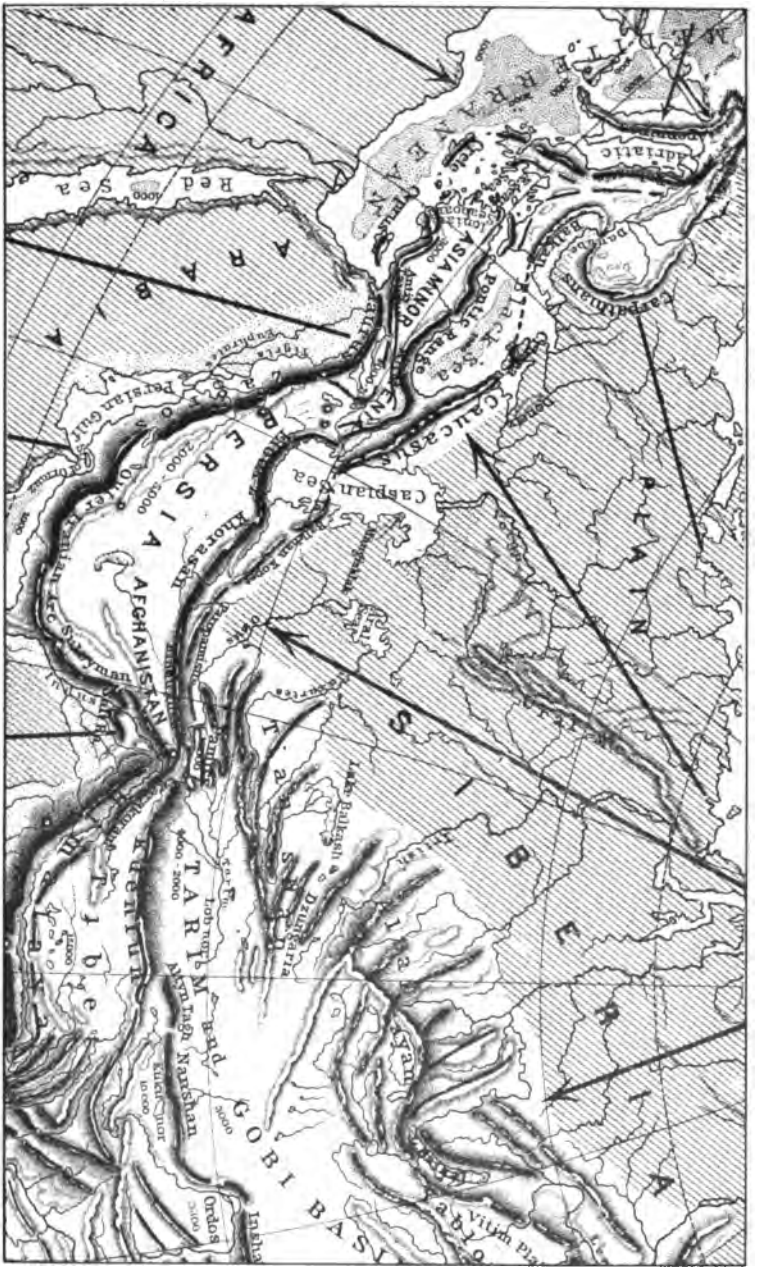

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the southern shore of the Black Sea. The Pontic range forms a bow of wide span and gentle curvature, ending in the hump of Anatolia, where it meets the arc of the Bithynian border hills.

The parrallel series on the outer margin of the elevated area commences with the outer arc of the Hindu Kush system, the severly bend and S shaped Salt Range. Thence it proceeds into the mountains which flank Persia upon the east and belong to the outer Iranian arc. The bold sweep of this arc into the chain of Zagros may be recognized by a glance at the map. The greater protraction of the north western arm of the bow, is a feature which may be traced in the configuration of the most of the great Asiatic chains. The clean and uniform outline of the curve, broken only by a slight indent at the straits of Ormuz, which may be answered by the bend in the inner system which is already noticed on the east of Gaspian Sea. The outer Iranian arc effects a junction with the Tauris Ranges along two parallel but fairly distinct orographical lines. Of these the inner line crosses over from the Zagros to the Ararat system, known as the Aghri or Shatin-dagh. It is in the Shantin-dagh that the bend to the west-southwest is effected, which may be followed through a series of volcanoes into the Anti-Taurus and the Mediterranean range. The outer line is formed by the Kurdish mountains. This principle chain of Taurus extends to the coast of Syria and emerges from the sea in the island of Cyprus and in many a headland and island of this Anatolian coast.

These double series of arcs, from Hindu-Kush to Mediterranean, meet or almost meet at three distinctly traceable and widely separated points. Such approximations occur in Hindu-Kush, in Armenia, and in the mountainous districts which border the Ionian sea board. We can scarcely doubt that they are due to the incidence of a strong opposing force, moving from the south and causing the arcs to be constricted, the range to be piled up one behind another and mountain development to assume its' grandest forms. It is probable that the resisting pressure has been furnished in the first two cases by the Indian and Arabian peninsulas. Another feature, less obvious but not less noteworthy, is furnished by the fact that in Armenia and Asia Minor the arcs have been fractured in the process of bending over at or near the points where the approximations between the two

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series have taken place. The closer the constriction the sharper, of course becomes the curve and the greater the tendency to split. In Anatolia the union of the series has resulted in complete fracture; the folded area sinks beneath the waters of the Aegean to be represented by the islands which stud the Archipelago, and, further west, by the mountains of the Dalmation coast.

On the east of Hindu-Kush we are as yet in want of sufficient material for so convincing an analysis as the researchers of geologists have rendered possible on the west.

In eastern Asia a vast area of elevated land is bounded both along the inner and the outer margins by mountain system of wide extension and great heights. Such are the systems of Altai and Tean-Shan upon the north, and the mighty bow of the Himalayas on the south. Probably the Kuenlan range carries over the inner series of Western Asia, extending eastwards from Pamirs and serving as buttress to the immensely elevated plateau of Tibet. If this view be correct, then the Tian Shan and Altai systems may perhaps be regarded as minor earth-waves, following close upon the heels of the Kuenlan and supporting the highlands of the Tarim basin and the desert of Gobi, the Han-Hai or Dry Sea of the Chineese. The echelon of mountain ranges, which extends from Hindu-Kush towards Behring Sea, forms constant curvature of the arcs towards the south, until, in the Altai group. The eastern arms of the bows are protracted even further towards the north, to contrast the low-lying plains along the western ends of the echelon with the lofty high-lands of Mongolia on the east. The necks of the valleys issue upon the depression of Siberia and the low country through which the Oxus and Jaxartis flow.

In Western Asia the elevated area with it's flanking ranges is borded on the north by the northern Paropamisus and further west by the Caucasus chain. The Paropamisus may perhaps be regarded as the most southerly of the many branches which belong to the system of Tian-Shan. Geologists connect Paropamisus with the Caucasus and trace the links of the broken chain to the mountains of Krasnododsk on the Caspian, whence a submarine ridge carries the line into the mountains of Caucasus, to be protracted far to the west, through the Crimea and emerge from the waters of the Black Sea in the Balkans, Carpathians

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and Alps. In this manner we see described on the north of the Asiatic highlands, with their series of inner arcs, a further arc of immense span and wide curvature, which is represented on the east by the northern Paropamisus and by the Caucasus on the west. Both these ranges may best be viewed as independent of the inner series but Paropamisus is closely adpressed to the inner arc of Persia, and Caucasus is joined at a ingle point to the series namely by the Meschic linking chain. Lines of elevation similar to that which is traced from Paropamisus may be discovered, although with less orographical distinction, proceeding westwards and struggling over towards Europe from the more northerly branches of Tian-Shan; they are almost lost in the great depression of the Turanian lowlands, but they follow arcs of increasing width of span.

NATURAL BARRIERS

Although Armenia is closely linked with her neighbors and is not separated by any natural frontier from Persia on the east or from Anatolia on the southwest, yet it is divided by some of the most effective of natural barriers and natural distinctions within itself.

The northern peripheral region is an effective barrier between Armenia and the coast of the Black Sea throughout their prolongation upon the confines of the tableland and has drawn the natural frontier inward in the neighborhood of Ispir. Across the valley of the Chorokh is the northern border heights of the plain at Erzerum.

The southern region is an analogous zone composed by the main chain of Taurus separating the highlands from the low-lying plains of Mesopotamia and butteressing them upon that side. This chain appears to have succeeded in accomplishing the curve into the Iranian direction without undergoing fracture to any material extent. The spine of range may be followed along the southern shore of Lake Goljik to Palu Mountain east of the town of Palu. Thence it is taken along the plain of Chabakchar and left bank of Murad River to the confines of Mush. Conspicuous with sharp peaks it stretches past the depressions of Mush into the landscape of Lake Van. Through

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the Karkar Mountain and further east through the Bashet Mountain west of Bashkala, it makes steps southwards to the threshold of Basin of the Great Zab; and the elevation may be traced on the further side of river in the peaks of Jelu Mountain, said to attain a height of between 13,000 and 14,000 feet.

The Karabagh region is another important barrier combining in miniature many of the characteristics of the Armenian highlands. An inner plateau region flanked by peripheral ranges. This chain extends the area of highlands for some distince towards the east when after commencing to incline in an east-south-easterly direction it effects a junction with the Shah Mountain. The last named ridge takes frontier along the eastern

shore of Gokcha to the confines of the Karabagh; and the elevations may be traced through this spine of northern Karabagh Mountain across the Kur to the range which faces the Caspian Sea.

Ararat or the Aghri Dagh system constitutes the principal intermediate line of elevation between the northern and the southern zones of peripheral mountains. This range carries the natural frontier between the two divisions from the Kush Mountain (11,262 ft.) in the west to Little Ararat (12,840 ft.) in the east. The space between these two ranges is a distance of 100 miles and throughout that space the chain is made up of such lofty peaks as the Ashakh Mountain (10,723 ft.) Perli Mountain (10,647 ft.), Salaka Mountain (10,644 ft.) and Khama Mountain (11,018 ft.). The passes reach from 7,000-8,500 feet;

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while the level of the plain of the Araxes does not exceed 3,000 ft. nor that of the plain of Alashkert 5,500 ft. In appearnce the barrier as a whole resembles the mountains of peripheral region; there are the same deep valleys, jagged outlines, precipituous slopes. From the western shore of Lake Baluk, an upland sheet of water lying at a level of 7389 ft. we may trace extension of one branch of the system along the water-parting between Murad and Araxes. Thence the elevation may be followed into the southern peripheral region, forming a splinter from the chain of Zagros which has struggled upwards through the plateau country to its very heart. The more northerly and principal branch consists almost exclusively of recent volcanic mountains, stretching from Perli Mountain, west of Great Arart. In this neighborhood the line is taken up by the fabric of Ararat, raising the barrier by slow stages to nearly 17,000 ft., and having an axis from northwest to southeast. The sequence comes to an end in the little Ararat, whose slopes descend on three sides to fairly level plains.

TOPOGRAPHY.

A. Armenia.

A. The northern border range forms a wall which hangs together completely in the north of a high plateau consisting of morphologically separated elements which is regarded as uplift or sunken portion of a hard resistant formation, which in consequence of tangential pressure in the earth's crust was broken instead of being thrown into folds. From the west towards the east the following order is observed.

(1) The Pontic region, which forms a border on the Black Sea, bounded on the south by rivers of Kelkid and Chorokh and coming to sharp ridges in the Mta-Skaro, south-westward from Batum.

(2) The Imeritian and Thrialitic rgeion, which between the Armenian highland and the resistant Maschic horsts are interpolated. These regions are cut through by the picturesque Borjom Valley of Kur.

(3) The Somkatian regian southwestward from Tiflis.

(4) Closely linked Gokcha-Karabagh regions. This region

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repeats on a smaller scale the structure of the Armenian highland; namely, that of a central, relatively low volcanic plateau, which is bordered on either side by uplifted formations of older folded rocks; namely the Gokcha and the eastern Karabagh and Talish regions, being on their sides separated by the Ahar depression, which runs in equatorial direction, just as the Gokcha and east Karabagh regions are separated by the Terter depression.

B. Southern border range show similar structural relations to the Armenian highlands. Here the high Tauric region of old slate borders on the relatively low-lying region of the lake Van and of the plain of Mush. The Tauric region consists probably of several smaller blocks. It acts, however, as a whole and its rivers all have consequent courses; towards the west it continues in the Ousounyaila, toward the east in the high Jelu Mountain. The southern spurs of these mountain chains can indeed be taken as the western extension of the Persian Zagros Mountains.

C. The Central highland possesses a significant average height. It is, however, as its geological structure shows, in comparison to its still higher neighboring mountains in the north and south, a region of relative lowness. It may be devided into the following three zones:

(1) A central volcanic zone with outspread lava fields which are broken into small dislocated blocks filled often with lakes. Of these today Gokcha, Van and Urmi are the largest.

(2) The Kilkid Chorokh zone lies on the inside of the Pontic region and consists of Antituric (S. W.—N. E. stretching) folds. Here vulcanism plays only a subordinate part.

(3) Daralagoz zone, including the west Karabagh which in similar manner lies on the inner side of the northeastern border chain of mountains. This zone is a region of Iranian (N. W.—S. E.) folding and shows a very complete succession of shales but only sporadic vulcanism. From the eastern border chain it is separated by the volcanic Akhmongan-Gotcha-Central Karabagh zone.

A central spine of folded rocks extends through Armenia from east to west. Its continuity is broken by diagonal depressions. In this way the line of the Antituric Mazur-Merjan Mountain is broken by the Erzingan depression. It is continued again in the

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Keshish, Melpert, Miriam and Terjan Mountains to form the southern border (Palandoken and Khan Mountains) of the plains from the Erzerum to Paisn, and to bend easily in the Shatin Mountain, and after a new interruption in the deep depression of the Middle Araxes, to rise through the Zynlerly and Daralagoz to the high chain of west Karabagh which turns to the direction of Iran.

B. Anatolia.

A. Northern border range.—Anatolia is skirted on the north by broken series of mountains radiating from the northern Armenian uplands. The Pontic range here forms a bow of wide span and gentle curvature ending in the hump of Anatolia where it meets the arc of the Bithynian border hills. These uplands merge imperceptibly in the Central Plateau which are themselves furrowed in every direction by river valleys. All these show similar structural relations to the Pontic chain, and are crossed at various ponits by passes generally at low elevations and of moderately easy access from the Black Sea to Central Plateau leading from east to west.

1. Trebizond over the Kolat-dagh to Erzeum.
2. Samson to Amassia.
3. Sinope to Amassia.
4. Ineboli to Kastamouni and Angora.

B. Central depression or Lycaonian Plateau.—A plateau formation prevails throughout the interior of the peninsula forming an extensive tableland at a mean elevation of from 2500—4000 feet above sea level and stretching northeast and southwest for a distance of over 200 miles with an average breadth of about 140 miles. Plateau rises from west to east and attains its greatest altitude above 7000 feet near Erzerum. Above this tableland rises several ranges, while over its surface are scattered a number of salt lakes, morasses and water-courses without any visible out-flow seawards. Its western face is broken by broad valleys, and only in case of Olympus (7600 ft.) rises much higher than 2500 feet. Plateau is buttressed on the north by Pontic chains which varies in height and rises abruptly from the sea. On the south it is similarly buttressed by the Taurus range which in places has an altitude from 7000—12000 ft.

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C. The southern border ranges.—All the more elevated lands and main ranges are massed along the Mediterranean seaboard, showing similar structural relations to the southern Armenian highlands. These highlands consists both of Anti-Taurus and Cilician Taurus chains extending along the Mediterranean coast by the local names of Isaurian, Pisidian, and Lycian Taurus, all belonging to the same orographic system. The range is interrupted only by a slight intervening faults. This system is also crossed by passes at various point as follows:

1. Syria, on the east, is separated from Cilicia by the gorge of Jibum and broken down to the lowlands of Mesopotamia in a series of rock terraces seamed by deep ravines.

2. Anti-Taurus is separated frm Cilician Taurus by Zamantia-Su, a tributary of Sihun.

3. Anatolia is separated from North Syria and Euphrates Valley by a deep gorge named Gulek-Bogaz or Cilician gates. This is 3300 feet above the sea-level, and runs about 30 miles north of Taurus over the Taurus.

4. A pass 100 miles west of the above leads from Karaman southwards to Gok-Su valley.

5. A pass further west about 150 miles.

6. A pass connecting Isbarta southwards with Adalia.

This range approaches the sea except where the Pamphylian and Cilician plains intervene. It is a volcanic region on its interior, the line of volcanoes stretch from Karadagh to Argeaus and all lie extinct now.

D. Ionian Seaboard. In this region the double series of arcs extending from Hindu-Kush have met. Through the process of bending over the arcs are strongly fractured. The folded area has sunken beneath the water of the Aegeous to be represented by the islands which stud Archipelago and further west by the mountains of Dalmation Coast. This region is also strongly volcanic.

E. Eastern ranges and connecting links.—No hard and fast line could be drawn to separate Armenia from Anatolia on the east, but the western extension of the Tauric system forms a semi-circular arc, hanging as a wall against the Lycaonian Plateau on whose centre rests the Mighty Argeaus. This wall sweeps over the banks of Kizil-Irmak, and merges into the Pontic chain

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by transverse and parallel ridges. The Karabel-Dagh, which runs from the great bend of Euphrates at Egin to the head streams of Kizil Irmak, connects the mountain chains of inner arc (Pontic), to the outer arc (Anti-Taurus and Taurus). This connecting link separates Armenia from Anatolia, as well it separates Cilicia from Upper Armenia.

PHYSIOGRAPHY.

A. Armenia.

The country of Armenia takes its place as an integral member of the system of tablelands, buttressed by mountain ranges which extend from the Hindu-Kush to the Mediterranean Sea. Most of the characteristics which are found in either of Persia on the east or of Anatolia on the west, are prevalent in Armenia to a greater or lesser degree. The stratified rocks extend across the whole system. The salt deposits which are spread so widely over Persia, are not among the least remarkable of the surface features of Armenia. Considerable depressions of the surface of the highlands are phenomena common to all three countries and the same may be said of the volcanoes which are dominant in Armenian landscapes but are not wholly absent from the contiguous territories on either side.

The idiosyncrasies which distinguish Armenia as a whole from the other members of the series is, in the first place, the greater elevation investing her territory with the attributes of a roof to the adjacent countries, from which the waters gather to be precipitated in different directions and to find their way not only to the Black Sea and Caspian but also by almost endless stages to the Persian Gulf. The prominent part which has been played by recent volcanic action is another impressive phenomenon. Both these manifestations are explemified in a striking manner by the surface features of the rectangular area of the more northerly sphere.

The higher plain levels of this region are situated at an altitude of some 7,000 ft. above the sea. The uplands which give rise to the Kur in the district of Goleh must come very near to this level. The parting of the waters of the Kur and Araxes near the village of Shishtapa, in an open landscape which may be

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compared to rolling downs, lies at about 7,000 ft. while of smaller sheets of water Lake Topo-ravan, with 6,876 ft., and the Apa-Gol with 6,706 ft., slightly better this already considerable figure. Where the plateau falls away to the abysmal canon of the Araxes its edge is nearly 6,500 ft. high.

The Town of Ardaban stands at a level of 5,840 ft. and Kars of 5,700 ft. Alexandropol, the principal City, occupies the hollow of a vast basin-like plain; yet it is over 5,000 ft, above the sea. These elevations are much greater than the average even in Persia though in the frontier province of Azerbaijan and along the edge of the southern peripheral mountains.

The process of gradual uplift of the region by earth movements has been attended by eruptive action, flooding the country with volcanic matter, levelling inequalities of the ground and adding to the height. It has been estimated that the volcanic deposits laid bare in the ravines of the streams which descend from the radial Dochus-Punar attain a depth of hundreds of yards. A similar phenomenon is made manifest in the canon of the Araxes, a cleft which in the neighborhood of the village of Armutli, west of Kagisman, has a depth of about 2,000 ft. and a width on top of at least a mile. There the sedimentary deposits are overlaid with tuffs and lavas in a belt over 300 yards deep.

The Armenian highlands have been the scene in olden times of great volcanic activity. The position of the remarkably numerous volcanoes of Armenia is by no means fortituous, that on the contrary they have invariably arisen along the lines of fracture, and that the volcanoes which occur at points of intersection are proportionately larger. The most interesting principal operative in this country is the series of volcanoes along meridinal lines. Such groups pursue a course at right angles to the strike of the rock with the area of the peripheral mountains. In this connection the plateau region occupies the apex of the bend over the inner arc. Lines of fractures have been thrown out at right angles to the folding and eruptive agency was fastened upon these weakened zones of earth's crust. The points of emission of volcanic matter are in some cases true volcanic, in others mere pistules or fissures of varying extent.

The tendency to a strong pronounced plateau country is in Armenia, especially in the southwestern territories, indepedent

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of volcanic action. It is a plateau, as a whole that may be regarded as an area of reltive depression between its northern and southern border ranges. The depression, caused by subsidence of blocks of land along the lines of fracture, became filled by lakes during different Geological Series. The lavas and tuffs of the numerous contemporary volcanoes.became interbedded with the lake deposits, and assisted in levelling the pre-existing inequalities of the ground. In this way plains were formed varying in size from the great Mid-Araxes in depression at the foot of the Ararat to the plains of Alashkert, Pasin, Erzerum, Khinis, Mush, etc., down to little fertile plains such as Bashkent, Gandemir, etc.

Sharp peaks precipitous slopes, narrow valleys, and swift streams and rivers compose the landscape. The basinlike appearance, the long parapets on the northern and southern edges, in one case culminating in volcanic peaks of Palandoken and Eyerli, in the other distinguished by eminence of Bingol. The waters of the plateau converge together in the shape of two fans, as they are precipitated from the highest levels towards the east, burying themselves ever deeper into th volcanic soil.

The surface of the country is composed of limestones with intrusive serpentines and lacustrine deposits capped by sheets of the ubiquitous lava. The stratified rocks are prominent, emerging from the volcanic layers or only capped by a thin sheet of lava. Dominant among them are the limestones of various geological periods, when the greater part of the country must have been covered by a lake of fresh or brackish water. Intrusive in earlier limestones are found a variety of old igneous rocks, such as diabase, gabbro, and serpentine. The serpentines combine with the limestones to form rounded hills or downs with soft outlines. Sometimes a cap of lava has preserved a particular piece of limetone and the result has been a summit with a point like that of a needle overtopping adjacent and undulating forms. Where the old ingenous rocks occur in a zone a sombre landscape is forthcoming as, for instance, above the northern shore of Lake Van, between Akhlat and Adeljivas; or when the highly marmorized older limestones have the upper hand, there ensues sterility and glaring light. These later rocks have a fairly wide extension and compose prominent lines of mountains; for example, they have bestowed upon the plain of Khinis its north-

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ern boundary.

A rather later series of limestones are placed on the very threshold of the Armenian tableland; and they are distributed in a wide zone over the northern districts of Armenia, extending all the way from the Merjan-Musur Mountain in the west to those represented by many a summit of the deeply eroded Chorokh region. The block of heights on the north of the Western Euphrates is composed to a greate extent of such limestones; and both in the neighborhood of Kop Pass, and northwards from the pass of Koshab Punar.

Later still in date, and of almost constant prominence in the landscape both of the plateau region and of peripheral mountains are the limestones more usually associated with softer features, especially when they are interbedded with shales. The incidence of their impressive features at Palandoken line of height, on the south of Erzerum and Pasin, and where they whiten the waters of Lake Van in the neighborhood of Adeljivas. This pretty town, which lies at the foot of a lofty cliff is composed exclusively of white chalk. Along the road from Akhlat deposits are prominent over the area of Central Tableland, and numerous corals are observed imbedded in rocks. Limestone emerges on the farther side of the plain of Khinis to compose the Zernek Mountain, continuing the outline of Khamur. The almost limitless expanse through which the Murad winds between Tatakh and Melazkert reveals most clearly its essential character as a country of rolling chalk downs beneath the covering of a cloak of lava. The southern limit of that expanse would seem to the eye to be volcanic. misled by the precedent of the immense extension of the train of Ararat. But where the barrier is at length reached it is found to consist of limestones forming a pedestal for the fabric of Sipan.

A less prominent surface features are the lake deposits crumbling in the hand with masses of fresh water shells. There can be no doubt that an epoch contemporaneous with the outpouring of lavas a lake or lakes extended from Erzinjan, Erzerum, and Pasin across the region now occupied by the central tableland, and through Khinis to the plains of the Murad and Sipan. The interior of Asia Minor and the tableland of Persia were covered with lakes at the same date; but that these were salt in

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the case of Persia is proved. Saline deserts which disfigure immense tracts of the soil of Iran prove this. In Armenia they have been productive of the greatest fertility, their wholesome sediments having mingled with volcanic matter and become constituent of rich brown loams. It seems likely that the purple sandstone and conglomerates along the northern shore of Lake Van are the representatives of similar conditions within the basin. It may be justifiable to suppose that the waters became gradually more shallow, until they remained only on the surface of the numerous greater and smaller depressions, which still bear their imprint to a degree which must be convincing even to an unpracticed eye. A chain of separate lakes was formed spread broadcast over the land, and washing the promonotories of the heights. Such lakes appear to have existed at Alexandropal and in the plain of Erivan over Pasin, the plains of Erzerum, and that of Erzinjan, in the districts of Khinis, Alashkert, Bulanik and probably Mush. They were drained away as a result of the increasing elevation of the land as a whole; and, probably, in some cases the process was accelerated by uplift, causing erosion of the adjacent barriers to be accelerated. The lakes which exist at the present day are almost exclusively due to lava filling in the mouths of valleys and forming dams on an immense scale.

A feature which has occupied a considerable amount of attention is the fluctuation in level of the lakes. The fluctuations may be of temporary and more or less permanent origin. All evidences point to the fact that such changes are of a temporary nature and that a period of increase is followed by one of decline. Such a change may be due to——

1. Ordinary climatic conditions such as the rainfall, fall of snow and subsequent variation in volume of rivers, and in activity of springs.

2. The economic state of the country and the extent of irrigated land within the water shed.

3. Opening or closing of subterranean issues.

4. Movements of earth crust.

The most probable explanation is that they are due to climatic conditions which, it is well known, are variously operative over cycles of years.

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The most obvious explanation of the gradual but permanent rise in the norm of lake level, furnished by the cause; which may be constantly operative, namely, the increase of sediment deposited over the bottoms.

B. Anatolia.

The Anatolian rectangle may generally be described as a plane inclined towards the Black Sea. All the more elevated land and main ranges are massed in the southern section of the peninsula, along the Mediterranean seaboard. The northern slopes of these uplands merge imperceptibly in the Central Plateau, which are thmselves furrowed in every direction by river valleys gradually broadening out and draining to the Black Sea. But in the extreme north, where the coast line advances in a vast convex curve into the sea, independent and almost isolated masses rise between the Kizil-Irmak and Sakaria basins, skirting on its northern edge an extensive central plain, whose deeper parts are still flooded by the remains of an inland sea. The ranges which follow at some distance the line of the southern shore, and which are broken into irregular chains and mountain masses, are mainly disposed in the form of a crescent with its convex side facing the Mediterranean, and thus corresponding to the northern curve turned towards the Black Sea.

Anatolia must be regarded as a western extension of Armenian highlands, from which it can nowhere be separated by any hard-and-fast line. The plateau formation prevails throughout the interior of the peninsula forming an extensive tableland at a mean elevation of from 2,500 to 4,000 feet above sea level, and stretching north-east and southwest for a distance of over 200 miles with an average breadth of about 140 miles. Above this tableland rise several loosely connected mountain ranges, while over its surface are scattered a number of salt-lakes, morasses and water courses without any visible out-flow seawards, beside several streams which find their way mainly northwards to the Aegean. The plateau is skirted south and north by two broken mountain ranges, which radiate from the Armenian uplands, Taurus and Anti-Taurus. Both these mountain ranges are crossed at various points by passes generally at low elevations and of moderately easy access. Of this

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the most important is the Geulek-Boghaz, or Cilician Gates, a deep gorge 3,300 feet above sea level, running about 30 miles north of Taurus over the Taurus, and conceding Anatolia with North Syria and the Euphrates Valley. About 100 miles west of these points the Taurus is crossed by a second pass leading from Karaman southwards to the Gok-Su Valley, and by a third 150 miles. Still farther west connecting Isbarta southwards with Adalia. The chief openings giving access from the Black Sea through the Anti-Taurus to the Central Plateau are those leading from Ineboli to Kastamuni and Angora, from Sinope to Amasia, from Samson to the same place, and from Trebizond over the Kolat-dagh to Erzerum.

The Anatolian peninsula forms in reality as well as in name a minature of the whole continent. Both consist mainly of extensive Central Plateau, with an inland and seaward drainage, and both are skirted by lofty ranges behind which most of the streams have their source, which find their way to the coast. But in Asia Minor the Alluvial plains developed by those rivers cannot be compared in relative extent with those of the greater Asia. The escapements of the plateau approach everywhere so near to the sea that no space is left for great lowland plains such as those of Siberia and China. There are a few low-lying and somewhat marshy tracts about the lower course of the Yeshil-Irmak, Kizil-Irmak, and Sakaria on the Black Sea, along the banks of the Meander below Smyrna, and about Adalia and Mersina on the south coast. But with these and a few other unimportant exceptions the whole peninsula may be broadly divided into two main natural divisions—the central plateau and the encircling ranges. This disposition of the surface has largely determned the limits of the 8 states into which Anatolia is divided for administrative purposes. Angora and Sivas comprise the greater part of the tableland, Adana, Aidin, Kastamuni and Trebizond coincide with so many distinct sections of the coast ranges, while Brussa and Konia alone include portions both of the plateau and of the seaboard.

The Anatolian plateau rises from west to east, and attains its greatest altitude, above 7,000 feet near Erzerum. On the south the plateau is similarly buttressed by the Taurus range, which in places has an altitude from 7,000 to 10,000 feet.

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Except where the Pamphylian and Cilician plains intervene, the range approaches the sea. Farther east it is separated from Syria by the gorge of Jihun, and breaks down to the lowlands of Mesopotamia in a series of rock terraces seamed by deep ravines. The western face of the plateau is broken by broad Valleys, and only in the case of Olympus (7,600 feet) rises much higher than 2,500.

The most striking features are the great central plain with its salt lakes; the abence of navigable rivers; Mount Argeous (13,100 feet) and its volcanic district to the south; the Subterranean flow of streams beneath the Taurus and a number of hot medicinal springs.

The great plain of Western Anatolia is composed of lacustrine deposits. Mount Taurus consists chiefly of limestone, the Pontic range of scheists and metamorphic rocks. Igeneous rocks occur in many districts, and some of the minor ranges are of granite.

The Central plateau consists of nearly horizontal strata while around the coast flat lying deposits are found extending up into the mountain regions. The deposits of the Central plateau consists of freshwater marls and limestones. Along the southeastern margin, in front of the Taurus, stands a line of volcanoes stretching from Karadagh to Aegeaus all lying extinct now.

TECTONIC FEATURES.

A. Armenia.

The central and least interrupted fold of the Armenian plateau may be regarded as the link between the Alburs of Northern Persia and the Anti-Taurus of Asia Minor. The Alburs folds after bending around to the northwest are broken off near Haran and only rise up again northwest of the great volcano Karabagh. The folds are cut through by the transverse valley of the Araxes below Ordubad and are continuous with the same northwest direction through the Karabagh region. The western Karabagh range is the highest of the folds reaching 12,832 feet in granitic Karabagh Mountain. It gradually bends around to W. N. W. through Dammry Mountains (11,093 ft.) and Salvasty Mountain (10,422 ft.) into the Daralagoz district.

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finally breaking off in the Zynlerly Mountain towards broad Araxes plain north of Ararat. Here the fold has undergone fracture and depression and has been concealed, not only by the lavas of Ararat and Alagoz, but also by the loess and alluvial deposits of the Araxes. A fragment, however comes to light in the Oligocene rather than in the Kegeljin Mountain near Kulpi. Then it forms Shatin Mountain the "spine of Armenia," with a dioritic axis and it bends round to a W. by S. direction dividing Pasin from Alashkert and Tekman. After passing through Palandoken (10,694 ft.) where it forms the southern boundary of the Erzerum plain, the line of height appears to die out in the Karakaya Mountain, and its place is taken on the south by the Zerdeji and Mirian mountains; thence the line crosses the Frat, to attain greater heights in the Melpurt and Keshish Mountains. Here it is interupted by the Erzinjan depression but it soon rises higher in Muzur Mountain. It is again traversed by the Frat above Egin for the third time and is con tinued to the southwest into the Anti-Taurus.

The Central Karabagh line forms part of the same Alburs-Anti-Taurus series. It is indicated first of all by the Ardebel depression, traversed by the S. E. N. W. course of the Kara-Su, and flanked on the west by the great volcano Salavan. The line is continued to the N. W. through the Cretaceous Karabagh. Surmounted by the tracytic Gaishtasar and Saigrama Mountains. Crossing the Araxes, its S. E. N. W. axis can be traced through the relative depression of central Karabagh plateau—a depression which has been more than filled up by the lavas and tuffs of numerous volcanoes arranged in series along its axis. The most important of these peaks are the Kehal Mountain, Ishakly, Kizil Bogas, Mukhortolian, Galingaya and Syrer-syrchally, all of which rise to heights 10,000—12,000 feet. The central Karabagh depression is then continued through Lake Gokcha into the Dachichak heights, and this line finally disappears beneath the northern lava-flows of Alagoz.

Starting once more from the Caspian, we find a series of S. E.—N. W. folds adjacent to the Alburs folds and rising up to form the Talish ranges. They are on the same line of strike as the folds which have been broken off, on the east coast of the Caspian, between Ashref and Asterbad.

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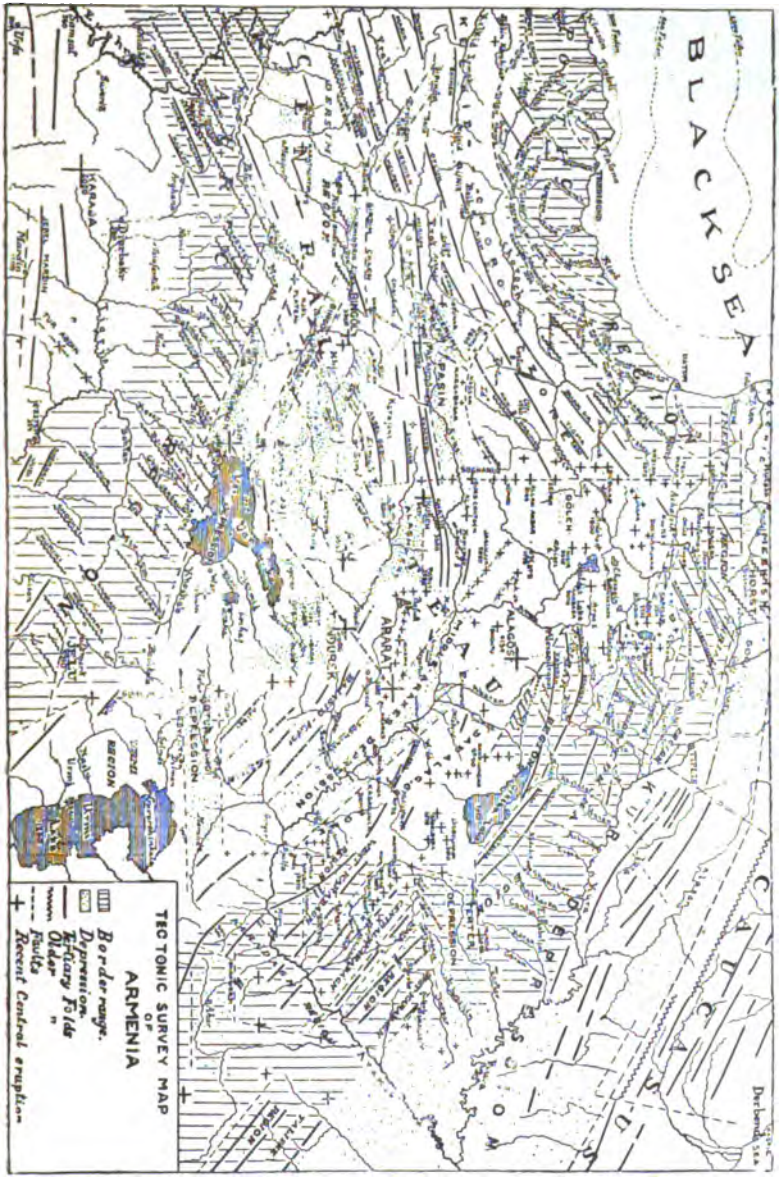

DATA TAKEN FROM F. E. OSWALD:—
Colored Geological Map of Armenia.

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It is evident that this interruption in their continuity is due to the depression of the area now occupied by the South Caspian. The Talish ranges disappear beneath the transverse valley of the Araxes and rise up again to form the east Karabagh ranges, among which Shasha lies centrally situated. They are continuous with the same N. W. direction as the Gokcha ranges, or so called Little Caucasus, occupying the space between Lake Gokcha and the Valley of Lower Kur. The richest ores of Russian Transcaucasian are found in these rugged Eastern Border ranges of Armenia. At the 45th meridian the folds begin to bend round to the west and consists of three main lines. Pambak, Bezobdal and Lialvar, which disappear completely beneath the volcanic plateau of Russian Armenia, with the exception of small outlier of Cretceous rocks near Medotappa Lake.

The Aglagan-Bezobdal fold already shows indication of bending around to W. by S. Although now completely hidden by vast accumulations of lava and tuff the continuation of these folds may perhaps be indicated by the W. S. W. direction of a part of the Kars-Chai Valley below Kars, and by the same direction of the volcano, Watershed, between the Lakes of Chaldir and Khozapian.

On the west side of the volcanic plateau this series of fold reappears to view, forming a N. E.—S. W. zone through Olti depression. They are still more closely indicated further to the southwest by the Cretaceous heights lying between the longitudinal valleys of the Chorokh—and further west by the synclinal area of the Varzahan plain and the Kelkid Valley. The chief line of these folds is marked by the heights of Akhbaba, Khoshabpunar, Jejen, Kop, Otluk, Sipikar and Chardaklu—a line which clearly defines the northern edge of the Frat basin, and which together with the opposite Muzar Mountain line of heights passes over into the Anti-Tauric system.

A still more northerly series of folds, the Thrialetic Imaretian Mountains, or Northern Border-ranges of Armenia is separated from the Lialvar line of folds by a hard, resisting block, a mass of gneiss, ancient schists and Palaeozic rocks. Among these folds four main lines may be divided:

1. Bielyiklinch to Yaglaga Mountain.

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2. Manglis to Tiflis.

3. Arjevan through Digorn to Lilo. This fold bends around to the W. S. W. of the Arjevan Mountain, through Karajakaya Sansislo (9351 ft.) and Oshara Mountain (8551 ft.) to cross the Kur Valley just above Akhaltsykh, it then disappears beneath the volcanic plateau of Karga Punar, Dokhus Punar and the Arzian Mountain. At the base of deep canyons of the Poskhov River the Cretaceous rocks of this fold are disclosed.

West of the Azian Mountain it is seen to reappear, bounding the longitudinal valley of the Imerkhevi River and it is continued to the S. W. between Artvin and Ardanush, into the Dedime Mountain (10,558 ft.) Thence it forms the inner line of the Chorokh and passes through the Vavuk Mountain to bound the Kelkid River on the right.

4. The line marked by Thrialetic-Imeritian Range through the Tortizi Mountain, across the Kur below Borjom, thence it is surmounted by the peaks of Salgalotto (8,288 ft.), Kageba, Nepiskaro, Gatewaria and Taginami. At this point it came over to the S. W. and after crossing the Chorokh just below the Ajaris confluence this lines proceeds along the coast behind Khora and Arkhava. It appear likely that the Karchkal Mountain (11,248 ft.) and parts of the Pontic Range have acted as a "horst" around which the folds have been curved and bent.

On the other hand the extension of this fold from Mitskhet eastward appears to lie through Mamkodi. A remnant of this fold may be seen in the Cretaceous outlier with S. E. strike which liesS. of Segnak, but this is an exception. It is concealed beneath Sarmartian deposits up to the 48th meridian, where it is indicated by the Eocene foothills of the Caucasus and it finally vanished beneath the Caspian.

Between the Anti-Tauruc and Tauric series of folds the Armenian plateau is only traversed by minor folds, chiefly affecting Lower Miocene limestone, e. g., Shurian Mountain, the Satah Mountain between Lakes Van and Urmi. All these folds show a general agreement with the Anti-Tauric series but their continuity is frequently broken by further scarps and concealed either by the ejectamenta of volcanoes or by recent richer lakes deposits.

The Tauric folds form a S. W.—N. E. series in zone between

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Malatia and Samasat and extend to the N. E. embracing the Palu. Here, however, they appear to meet a "horst." A southerly line of folding bends round this horst towards Sert. A still more southerly member of the Tauric series lies between Samsat and Urfa with a W. S. W. EN. E. strike it disappears beneath the basalt of the Karaja Mountain and rises again in Mardin hills, running nearly due to east. This line of folding crosses the Tigris above Jesireh and gradually bends round to the E. S. E. through Jadi Mountain and bends to Shernak Mountain, to pass into the Zagros Mountain, with a constant S. E. direction.

In Armenia the chief eras of mountain folding seem to have occurred in the Lower Permian, Antitithonian and Post-Oligocene priods, and in all of these the resultant pressure came from the south, i. e., from the Arabian tableland. Th northern limit to all this mountain folding in Armenia was formed by the great granitic "horst" of the Meschic Mountains. The Caucasus in this time was represented by an eliptical island, lying to the north of this resisting mass, and was only sligtly affected by the force from the south. But in the Post-Miocene era of mountain making to which the Caucasus owes its present great development, the force produced from the N. E. and by this time the sediments of Armenia has lost their plasticity and could not undergo any further folding. This hard, unyielding area now became fractured mountain blocks, most of which show parallelism to the Caucasus and are as much an expression of longitudinal stresses in the earth crust as the folds of the Caucasus itself.

The lines of fracture in Armenia which are due to the Post-Miocene mountain making can be divided into three classes.

1. Fracture parallel to the Caucasus, N. W. S. E. They have given rise to the depression of the Lower Kur from Gori to the Caspian and Kokcha-Karabagh-Savalan zone. The Kars-Ararat-Nakhichevan zone, the Alashkert zone, the Erzerum-Aladagh-Sahend zone, the Khinis-Melaskert zone, the Gum-gum-Liz zone, the Erzingan-Lake Van zone and the Diarbekr zone.

2. Two fractures, almost meridianal (N. by W. to S. by E.) lying on either side of the Meschic "horst" and in all probability directly due to its resistance. The western line runs from Elburz, through the Arzian and Sohanli series of volcanoes to Kuseh Mountain, and thence to Sipan; the eastern line extends

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from Kashet through Alagoz to Ararat and along the Turko-Persian frontier to Rowanduz.

3. A fracture crossing the Armenian Mountain folds at their concave bend, running from Karadagh through the high volcanoes of Armenia have arisen along this line, especially where it intersects other lines of fracture. This line may be traced southwrds into the great rift of the Jordan Valley, the Red Sea and through East Africa as far as the rift Lakes Tanganyka and Nyassa. Perhaps another line may also be traced radiating from the Karaja Mountain through the volcanic Bingol Mountain and Palandoken to Erzerum and Devehboyum.

B. Anatolia.

Naumann distinguishes three great folded arcs and a part of a fourth in determining the trend lines of the structure of Anatolia.—

1. The East Pontic Arc: it borders, in the northeast, the shore of the Black Sea, extending from the east towards Sinope. Abich justifies the separation of East Pontic Arc by the southwest trend of the ranges, on the left side of the Chorokh.

2. The West Pontic Arc: this is joined by the first, the southwestern parts of which (Phrygian zone) approach the inner side of the third arc. Naumann mentions a fold at Angora overthrown to the east-southeast, and towards Polatly, further westwards, there is horizontal tableland. For the stretch of the country, more than 100 Km. long, which extends from Heraclea to beyond Amasra, and is distinguished by the presence of coal measures, the whole district exhibits the character of a faulted-down than of a folded country. The convincing testimony to the existence of a West Pontic Arc is afforded by the steeply turned stratified series in the valley of the Sakaria, extending from Balabon upwards, past the Lefké and Vizirkhan.

3. Tauric Arc: this surrounds the Lyaonian plain, Cyprus forms part of it; towards the west it joins in syntaxis parts of a fourth arc. According to Naumann, an inner zone of the Tauric folds, coming from the northeast, runs within the bend of the Halys with a southwest direction towards the northeast of the Lyaonian depression, and breaks off against the border. Near Kaisarieh, east of this region, rises the mighty Argeaus,

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and here begins the zone of volcanoes which border the inner side of the Tauric Arc in a regular semi-circle. The problem of the tructure of this range is not yet solved. Generally speaking, the rocks, in accordance with the outer form of the chains, strike to the northeast, parallel with the Vulcan range on the one side and the Amanus on the other; the Mediterranean beds of Tertiary age are deposited against a range folded in this direction.

4. Eagian Arc: the part of the fourth which with the third arc forms re-entrant angles. The structure of the west coast of Anatolia is as follows:

a. From Crete an arc runs to the northeast through Kasos to Rhodes, where it meets a shorter segments coming from a northwest direction.

b. The volcanic arc extends from Santorin into Nisyros.

c. In the whole of the southwestern part of the continent a northwest strike prevails as far as the coast of Caria and onwards to Samos: this is the western wing of the Tauric arc, which encloses the Lyaonian plain.

d. Between Smyrna and Chios a north to north-northeast strike appears and is maintained through the Spalmatori islands and Mitilini to the plain of Troy.

e. The western limit of the Tauric Arc can only be followed with tolerable certainty as far as Samos. It is not sure that the ranges directed to the north and northeast should be included with it.

A syntaxis exists in the proximity of the west coast of Anatolia.

A northeast to east-north strike prevails on the European mainland (Tekir-Dagh, Kuru-Dagh) and as far as Samothrace, and perhaps also in the Carboniferous land of Balia-Maden. In the south this direction is reprsented by the volcanic line to Nisyros, and further by the line passing through Crete and Kasos to Rhodes, and the lofty mountains of souther Lycia. These regions are included among the eastern ends of the ranges of the Dinaric Arc.

A north and south to a north-northeast strike is met on with the southern border of the plain of Troy, in Mitilini, Chios, the Spalmatori islands, the peninsula of Karaburun, and as far

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as Smyrna. These areas probably answer in part to the Dinaric Arc and in part to the region of Syntaxis.

A northwest strike makes its appearance in the valley of the Sakaria in the neighborhood of the Olympus of Broussa, then in the southwest of Anatolia as far as Samos, thence to the coast of Caria and to a restricted part of Rhodes. These tracts are the western ends of the Tauric Arcs.

The tectonic feature of Anatolia is, unfortunately, not very well known, and also we do not know very much about the extension and the location occupied by the Tertiary folded zone. It is a fact that the masses are, during Tertiary, removed by vertical compartment, and have been dislocated after the Eagean depression forming a real folding. Folding predominates in the northeastern part of the peninsula, along the Pontic series, in the chains of Kos, Cilician Taurus, etc.

Anatolia, as a whole, represents one part of the recently folded crust forming a natural link between the European Dinarides—Balkans and the Asiatic folds of Iran. It is buttressed by the primitive mass of Arabia on the south, as Himalayas by the India. But, in some intervals of Tertiary folded mass, some vast regions are escaped this movements. Some of them are only subjected to vertical displacement in the fashion of European Hercynian Horsts. Upon this large space is established a tabular regime which could, very likely, be compared with the Pre-Balkanic plateau or with the Caucasus.

The Eocene is often laid horizontal or is only depressed having been inclined along the fault lines. Occasionally the Cretaceous also look tabular. The necessary informations are lacking to confirm whether they are primary or secondary movements. They are broken only before the Cretaceous or Eocene. In comparison with European chains they generally look like the primary foldings become insensible in the Tertiary.

Between the two folded chains, one bordering the Black Sea coast, and the other Mediterranean and Cilicia, we notice a tabular compartment, vertically moved, and interpolated same way as Tibet according to Naumann.

On the north, along the Black Sea coast, in Pontus and east Paphalgonia, there is a primary zone folded in Tertiary. This extending east-west constitutes the Pontic chain. This chain is

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notably represented by the Cretaceous limestones and flysch, with a great serpentine manifestation. The line which connects this to European chain is very imaginary. According to Suess it is the incurred succession of the Eagean fold. Further up to the west of the course of Halys the grounds look very much transformed, while the recently folded regions look composed of horizontal plateau where primary important masses are predominating.

Naumann shows that the region situated on the south of Bithynia and Paphlagonia, between Adabazar and Kastamuni, represent the Eocene and probably Cretaceous in a horizontal strata laid upon the Jarassic. This is strongly folded afterwards. Along the line leading from Scutari to Angora near Ieni-Chair, in the gorge of Sakaria, between the Biljik and Lefké. Naumann also shows, in wide extension, the horizontal Eocene recovering the redressed beds, so that all this compartment is at least laid horizontal since the Cretaceous during a period when the orogenic efforts attained to their maximum.

The retrogression (Schaarung) of Anatolia, which is supposed toward Sinope, to bind the northeast branches of the west to northwest is certain. The same degree of uncertainty exists in the region of western Anatolia where strongly mineralized.

But in all cases the Tertiary dislocations are abounding in this group. The eruptive manifestations are very frequent there, especially along the depressed zone as the basin of evaporation without any outlet from Lycaonia and Cappadocea. The pace of the metallic minerals contributes to accentuation in the most part of Anatolia, the one which is called Character of Mediterranean.

Coming to the south, the second zone along the Cilicia, Mediterranean and the Gulf of Alexandretta, is also notably folded like the Pontic chain on the north. The most northern branches of this chain resembles the one which manifests itself in the island of Kos and Rhodes, being persued from the southeast to the last axis of folding, passing through the Cyprus and Alma-Dagh. But it there interpolates the tabular zone in a condition which so far has not been defined. There are still other points where analogous phenomena is observable in dif-

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ferent geological periods. Bukowski has shown in Caria, near Davas, Lower Miocene laid horizontal upon the folded Oligocene, while little further the Pliocene same way, has taken part in the posthumes movements which is continued up to today.

Same way, the tabular system predominates in the regions comprised between Anti-Taurus and Armenian Taurus, effecting here the Cretaceous. Continuing these points, the folds soon stop, juxtaposing the tabular system in folded zones, with probable drifts notably along the Anti-Taurus.

GEOLOGY.

In general, Armenia geologically consists of Archaic rocks upon which are superimposed Palaeozoic and towards the south later sedimentary rocks, the last having been pierced by volcanic outbursts that extend southwest to Lake Van. Dominant among stratified rocks are limestones of various geological periods from Cretaceous and probably earlier to Plieocene.

The central plateau is especially covered or surrounded by such a thick or high mass of recent sediments and lavas that Mesozoic and earlier rocks seldom come to the surface. The Jurassic is recorded only from the eastern border range and from the region surrounding the Lake Van. Lacustrine deposits are also prominent geological features in Pliocene time contemporaneous with the outpouring of lavas in Central Armania. Strongly folded metamorphic rocks as marbles, mica and crystalline schists, schistose gneiss, slates and marl, etc., occur abundantly in Armania, especially in the Tauric range among the oldest rocks.

PRE-DEVONIC. Strongly folded schistose gneiss and other crystallint schists are the oldest rocks of Armenia. They have, as far as present observations indicate, a SW-NE strike., They form obstructive masses which offered strong opposition to later folding. The Armenian Taurus is the most important of these masses. It consists of layers of mica, quartzite and gneiss with which often serpentine (South coast of Lake Van), hornbende schist and finally granite (Vanik and Keser Valley) or diorite (Mikus and Shirvan) are associated. This slaty mass

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extends from Rovandus westward to the Ousounyalia (north of Albistan) where they are overlain by the Devonian. The same conditions appear in the most eastern part of Taurus. The great amount of interbedding of the slate and folded marble is typically seen at Tadvan on Lake Van in a stretch of only 100 ft.

Because of the rapid weathering of the mica schist to brown sand the summits of the Taurus Mountains consist of marble; while the mica schist, which lies above this, comes to light on the slopes, closed with a thick covering of sand.

The greatest height in this zone of metamorphism is reached by the Jelu Mountain. It is made up of slate, dolomitic limestone and porphyrites.

A region of the same tectonic importance, though not so well exposed, is the Meschic Mountains (Zirula dome) in the extreme norh consising of granite, gneiss and crystalline schist. The granite or granulite here is often penetarted by melaphyrs, diabases and porphyries. Granite gneisses, mica schists, and chlorite-schist occur in the upper Chram Valley, and in the Somkatian Mountains, as well as at other points in the northern border ranges.

Small occurrences of schists and gneisses occur here and there in the eastern border ranges, for example, clay and slate and sugar-grained marble (covered by Tourainian chlorite schists, mica schists and quartzites with white marbles, serpentines and schistose gneiss in the Pambak ranges and in the Darachichek Mountains). The chlorite and hornblende schists in Arpatal (Daralagoz), and in the upper Ochchital (West Karabagh) Valley appear again on the south side of the axis in Karabagh. On the bottom of some of the deep valleys of the north and east Karabagh old gneiss and feldspar porphyries under Jurassic rocks come to the surface.

Schistose rocks are reported from the Pontic region of the northern border ranges but their exact age has not yet been determined. Clay slates with SW-NE strike have been described from the lower Chorokh Valley at Artvin and from the neighboring Ardanush valley. They are overlain by the Lower Cretacic. A zone of rocks appear on the inner border of the Pontic Range (for example, of the Kharchkar Mountain,) and in the basin of Olti (Kanli and Akdagh Mountains at Id.)

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Occasionally the metamorphic series is seen in the inner region of the Armenian highland as at Arabkir (mica schists, sometimes graphitic). It extended through Dersim and appears above the graphitic mica schists) as far as the region north of Khinis, in the Shatin Mountain and in the Kisilja Mountain east of Lake Van.

DEVONIAN. Middle and Upper Devonic beds are reported from the Araxes Basin (south of Ararat) and from the Valley of its tributary, Arpa (Daralagoz), where they overlie red mica schist, sandstones and conglomerates. They extend southward into the Urmi Basin and eastward into the Karabagh, but are not known in the region between Ararat on the one side and their appearance in the Antitaurus on the other side. In the Araxes Basin they strike mostly NW-SE; sometimes (Davalu, Degma, Danga, Gyneshik) SW-NE; this can probably be attributed to posthumus influences because of the strike of the underlying slates. The Armenian-Devonian accords with that of Antitaurus and Persia and may be, owing to this similarity, divided according to the following general scheme:

Upper Devonian—

Zone of Spirifer verneuli. Red, thick bed of limestone with marly interlayers and clay slates. Fossils: *Spirifer archiaci, Spirifer tenticulum, Rhynchonella cuboides, Acervularia pentagona.*

Lower Devonian—

(3). Coral limestone, with very many *Cyathophyllum quadrigeminum.*

(2). Brachiopod limestone, with *Spirifer inflatus, Spirifer mediotextus, Rhynchonella letiensis, Chonetes.*

(1). Calceola tuff, marly limestone with calceola sandstone, *Cyathopyllum vermiculare, C. praecursor, caesopitosum, Cystiphyllum vesiculosum, Favosites goldfussi, Heliolites porosus, Stromatopora concentrica, Atrypa reticularis, Merista plebeja.*

CARBONIFEROUS. The limestones of the Carbonic age lie conformably above the Devonic from which they are distinguished simply by a general widespread, slight bituminous content, and the occasional appearance of Alum. The Carbonic is found in the same region as the Devonic, but stretches beyond in its higher layers; for example, on the south of the Araxes and on

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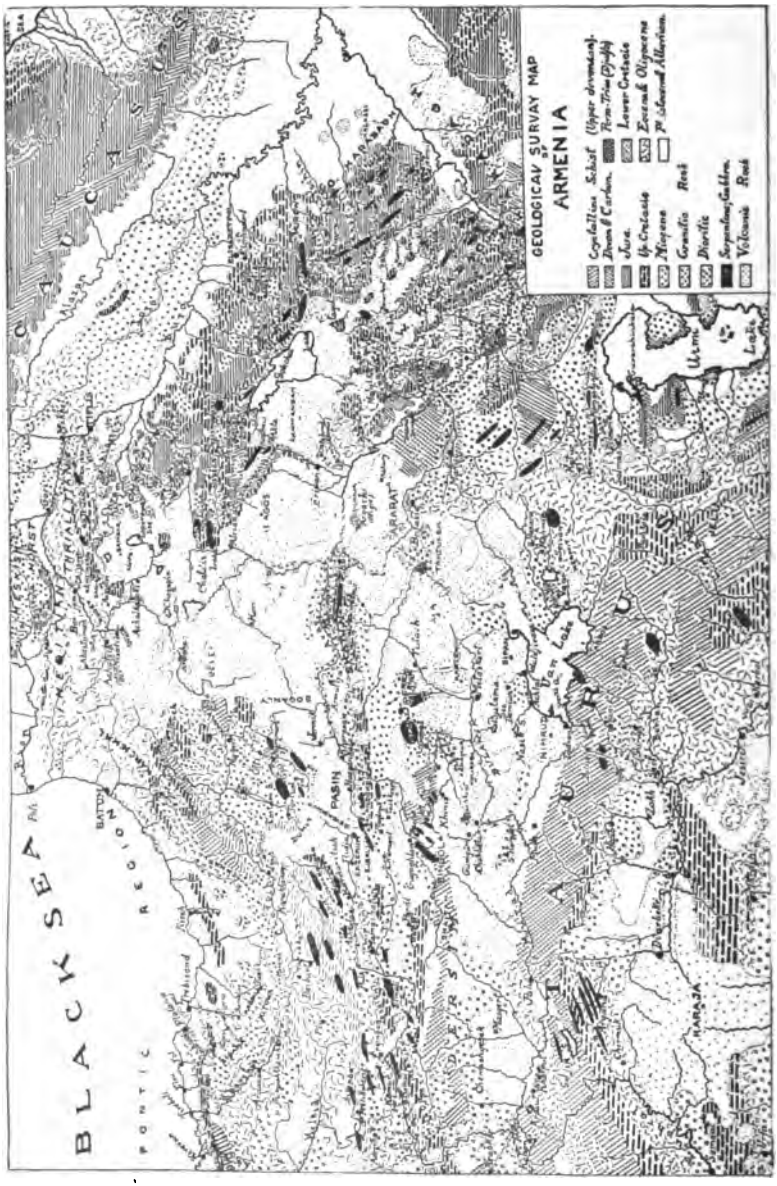

DATA TAKEN FROM F. E. OSWALD:—
Colored Geological Map of Armenia.

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the islands and the coasts of the Lake Urmi. A break in the disposition has occurred in Armenia in the second half of the Upper Carboniferous.

The general sequence of beds of the Carbonic is as follows:
Upper Carbonic—

Moskaus tuff. Fusulina zone, dark gray, often dolomitic lime with *Fusulinella sphaeroida, F. lenticularis,* Endothyra Bryozoan, lime algae, etc.

Lower Carbonic—

Zone of Products gigantes: coarse banded, bituminous coralline limestone with *Cystiphyllum murchisoni, Lithostrotion martini, Lonsdaleia floriformis, Productus gigantus, Spirifer striatus, Spririgera planosulcata.*

Zone of Spirifer, Marly limestone and shale.

(1). Crinoid limestone, with Platycrynus, *Dalmanella Michelini, Chonetes hardrensis.*

(2). Brachiopod layers with *Productus perlongus, Athyris ambigua, Spirifer tenticulum.*

PERMO-TRIASSIC. The Permo-Triassic limestones of Julfa on the Araxes and the neighboring Kasanyaila district were disposed in a bay of that sea which extended toward the Indian salt range. In contrast to the zone of Palaeozoic folds, in the Central Araxes district in, which eruptives of the same age are lacking, they show simply flextures with steep N. E. faults, and numerous bed veins of diabase and quartz porphyry. Carbonic, Permic and Triassic are comformable and folded together. In other places the Triassic of Armenia are not yet known. Possibly dolomite of the Jelu Mountain (in the Zab Basin) belongs to this formation analogous with the Triassic dolomites, of the western Caucasus. Rhetic with plant remains exist only on the eastern border of Armenia, namely, in the Alburz chain
Lower Triassic—

Quartzite of Negram, apparently with interbedding of Wellen-limestone with Werfen fossils.

Upper Permian. Upper Zechstein—

Limestones with the appearance of Wellen-limestone, and containing Chideru fossils.

Upper Permian. Lower Zechstein—

Julfa limestones with a rich fauna, especially of Ceratitidae

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and Brachiopods. Stage of Oteceras Julfense.

JURASSIC. LIAS. Rocks of the Lias have not yet been found in Armenia. But in the Urmi basin, beyond the boundary of Armeniais found the Toarcian. Here the association of central European fossil form is explained by advocating a connection, thorugh Roumania and Transylvania, with the Hungarian Sea.

The Liassic limestone of Azerbaijan indicates a more open sea than the fine-grained shaly, littoral facies of the Central Caucasus. Probably they were formerly continuous with the Palaeozoic sediments of Kessiktash at Angora in Asia Minor. This connecting sediment has either been denuded or still awaiting discovery. Perhaps in the Dersim distdict. The coal of Gernavig and Kamsakendi (north of Lake Urmi) is probably Liassic, but accessible knowledge seems to be against this idea.

DOGGER. BAJAOIAN TUFF. During the Bajocian time and several of the following epochs powerful volcanism existed in the neighborhood of the present eastern border range. The massive, in part submarine, outbreaks were inimical to animal life, so that only small remains occur in the seams of impure limestone which were interbedded in the great deposits of tuffs, sandstones and lava flows.

MALM. CALLOVIAN. The Macrocephallus and Anceps-zones are reported on the east coast of Lake Urmi, as well as in the eastern border range at Kabagtepé in the Shamshortal Valley, northwest from Elizabetpol. At the last named locality the facies indicate a sediment of great land.

In Armenia it is certain that neither Oxfordian nor Sequanian are known. The expressed volcanic disturbances which are noticed in the Sequanian of Central Caucasus were noticeably forerunners of the great Kimmeridgian faulting by which the Caucasus and the large part of Armenia was raised above the sea. These dislocations were accompanied by the outbreaks of most of the disbases and Melaphyrs of Armenia.

KIMMERIDGIAN is known from the Karabagh district. It shows the sponge and coral facies with those of the Natthein limestone. At its base lies conglomerate, which suggests a trangression in Middle Kimmeridgian time.

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TITHONIAN is known in the West Karabagh, namely, in the Kiaki Mountain and Trapassar Mountain (south of Tatev). In the coral limestones, the *Stylina decemradiata, Calamorphyllia pseudostylina,* etc., fossils are found.

LOWER CRETACEOUS. LOWER NEOCOMIAN (Valanginian has not yet been definitely recorded from the Armenian area, although it will probably be found to occur in the Karabagh region. According to Abich Neocomian strata are probably present on the Trapassar Mountain overlying Tithonian limestone.

The lower beds of the Valanginian are, however, well developed on the northern borders of Armenia in the Zirula dome (Meschic Mountains. Here in the S. W. part of the synclinal trough (SE of Kvirila) it consists of marls and marly limestones with *Terebratula pseudojurensis, Waldheimia moutoniana, Pygone diphyoides,* Chama, Strombus, etc.

MIDDLE NEOCOMIAN OR HAUTERIVIAN has a wide distribution on the northeastern, and northwestern borders of Armenia.

In the north, it is well developed in the Zirula dome in the marly sandstones and limestones, containing *Rhynchonella depressa, Exogyra couloni, Nautilus pseudoelegans,* etc., fossils.

In the east Karabagh is found the Neocomian marls and Exogyra and Lima. Farther south near Araxes is established the presence of Hauterivian beds. Farther south, in Azerbaijan, is found Hauterivian Ammonites at Gushaish, in the hills on the east of Lake Urmi. A fragment of a large Ammonite was also found in the massive limestone of a few miles below Muradkhan, on Kharshut River.

THE UPPER NEOCOMIAN (BARREMIAN) is present in Armenia only in its Urgonian facies, similar to that of Jura. On the northern borders of Armenia—in the Zirula dome—the Urgonian beds show evidence of a marked transgression, and of closer proximity to land than the very similar deposits in the west Karabagh.

Near Marelision the southern slope of the Zirula dome Requienia limestones and marls rest to the basal conglomerates and breccias derived from the underlying granite, and to the north of Molita they rest discordantly on Upper Jurassic clays' sandstones and tuffs. Urgonian is also well developed in the west

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Karabagh, but has not been recorded from any intermedate district. The limestone was noticed on the Trapassar Mountain containing characteristic Urgonian fossil (*Corals, Requienia ammonia, Nerinea*).

APTIAN. Very little is known as yet regarding the presence of this formation in Armenia except on its northern borders—on the Zirula dome and the south slope of the Central Caucasus. On the Zirula dome marls, slightly glauconitic, contain *Terebratula sella, Thetis major,* etc., fossils.

The presence of Aptian in the eastern Border Ranges of Armenia is established by *Exogyra aquila.*

UPPER CREACEOUS. ALBIAN is well developed on the northern borders of Armenia in the same localities as the Aptian, with which, indeed, it is in continuity. The Albian both on Zirula dome and on the southern slope of the Caucasus, represented by the sandy marls with *Discoides subuculus,* glauconitic sandstones with *Desmoceras bendanti,* marly sandstone with Crustacea and *Phylloceras velledoe.*

CENOMANIAN undoubtedly occurs on the south side of the Frat, almost due to south of this locality. The Cenomanian limestone rises up to form the Hach Mountain—the E. W. chain which divides the districts of Terjan and Kighi. On Zirula dome Cenomanian is well developed, consisting of slightly glauconitic sandstones and *Disoidea subuculus, Haploceras djumense, etc.*

TURONIAN is particularly well developed in the southern, eastern and western Karabagh district, especially in Alikulikent, in the gorge of the Bergushet River, where nearly the entire Cretaceous is laid bare. Here is recorded a considerable thickness of Turonian strata, much dislocated, dipping northwards and traversed by dikes of amygdaloidal dolerite. *Plagioptychus aguilloni* and large Radiolites and Acteonella fossils are much dominant. The only indication of Turonian in the Pantic region occurs near the confluence of Ardanush River with the lower Chorokh; a very thick series of limestones crystalline in places, overlying Cenomanian and underlying Senonian strata.

SENONIAN of Armenia is well developed in Karabagh region. In the west Karabagh at Alikulikent in the Bergushet Val-

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ley, the Senonian conformably overlies the Turonian; it shows a northerly dip, and is strongly dislocated and traversed by dikes of amygdaloidal dolerite. The lower part cnosists of thick beds of white fossils, chalky limestone containing *Echinocorys ovata, Inoceramus cuvieri.* Ammonites, etc. In the East Karabagh the Senonian is extensively developed in the form of fissile lithographic limestones. Generally the Senonian formation in Karabagh continued beneath the great depression of Kur, rising up again on the opposite side in the Caucasus. It is continued also to N. W. through the Gokcha Range. Near Elizabetpol the only recorded Senonian fossils are Foraminifera. Senonian limestones reach their greatest height in the region between the Debeda, Pambak and Akstafa Rivers.

To west and north the littoral facies predominate, especially in the lower part of the formation.

EOCENE. LOWER EOCENE. In the north of Armenia and in the Caucasus the Lower Eocene consists of a thick series of dark, argillaceous fissile sandstones and marls, harder beds of variegated shales and laminated limestones and flint and intercalated in the series but the only fossils are obscure impressions of thick stalked Fucoids (Chondrites. Tuffs and volcanic breccias frequently occur, together with contemporary diabases, andesites, dacites, and trachytes. They are well developed in the Akhalzik basin, near Borjom and Mikhailov.

The Lower Eocene is evidently represented along the southern base of the Taurus. At Arghana the Nummulitic Limestone is found to overlie carbonaceous marls; beneath these there occur brecciated and quartzose sandstones alternating with marls. Again between Ali Mountain and Arghana-Su intrusive masses of dialage rock have altered the carbonaceous beds into dark, sheared non-bituminous stone coal, with vitreous fracture. In all localities of Akhalzik Basin the fossiliferous Eocene beds are overlain by the Flysch facies of Upper Eocene, and this in turn by Oligocene. This facies is represented by marly calcareous beds, much laminated, with fucoidal remains, fish scales and impressions and teeth of *Lamma elegans, Otodus, Melatta sardinntes, etc.*

MIDDLE AND UPPER EOCENE. The middle and Upper Eocene of Lower Rion and Kvirila Basin show the same facies

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as that of the Akhalzik Basin. The Nummulite facies rather more marked here consists of clays, fissile marls and fossiliferous calcareous beds with *Orbitolites discus,* Serpula, Terebratula, etc. These fossils indicate the presence of both the Kressenberg and Priabona horizons. Numulitic beds appear in the upper valley of Pambak River, in the upper region of the Akstafa and Zanga rivers. The same horizon occurs in the Duchu and Terter Valleys, and the two areas were evidently in complete continuity through N. W.—E. E. Eocene zone, which borders Lake Gokcha on the N. and E. The finest section of Nummulitic beds in the Mid-Araxes region is near the monastery of Karmirvank, at the entry of the gorge leading to Julfa. Nummulitic limestone and fine grained sandstone are extensively developed in the Taurus Mountains, the southern border range of Armenia, especially in the plain of Apaud between Kharput and Keban Maden, containing *Nummulites pamondi, N. laeigatus, N. intermedius.* The higher parts of Taurus, between Kharput and Arghana consists of Calcareous strata abounding in Nummulites, overlying Cretaceous beds.

OLIGOCENE. LOWER OLIGOCENE beds occur in the Pontic region between the Karchkal Mountains and the Ardahan plateau. Here, above Satlel, in the gorge of the Samjel-robat River, a soft yellow, very compact, crystalline limestone with *Harpacto-carcinus,* Certihium, Turbo, Conus, etc., and corals and spines of Cidaris. The only remaining instance of Oligocene in Armenia is recorded in the Araxes gorge, a few versts above Julfa, half way between Julfa and Darosham. Here the horizontal Nummulitic limestone (overlapping permo Triassic) are conformably overlain by Oligocene, consisting of a very thick bed of an ash gray, calcareous sandstone, passing upwards into brown sandstones overlain by Sarmatian sandstones and conglomerates. Intercalated sandstone then occur between rather compact, calcareous beds, enclosing a number of shells (Gastropod) which are all changed into coarse-grained calcite, and difficult to determine owing to their fragmentary and altered condition. Ostrea, Venus, and *Natica glaucina* are characteristic fossils.

MIOCENE. LOWER MIOCENE is particularly well developed in the basin of Lake Urmi. The fossil collected on Ishakdaghi,

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Koyundaghi and the Shahi peninsula indicate:

(1) LOWER TDRTONIAN compact, rather porous limestone occasionally like travertine with *Alectryonia virlet, Thamnaroea polymorpha, Latirus crispus.*

(2) UPPER HELVETIAN, light yellow or white limestone and greenish-gray, coarse-grained, molassic-sandstone more or less compact, with sphathic portions, capable or high polish, sometimes partially translucent with *Polystomella quartrepunctata, Orbicella defrancei, Ccriopora anomalis, Spondylus bifrons, Clypeaster gunteri, etc.*

(3). LOWER HELVETIAN concretionary brownish-yellow limestone, breaks in great slabs, with *Pector convexocostatus.*

(4) Fragmental deposits, varying in thickness derived from

(5) Carbonaceous limestone.

A great part of the mountainous country between Khoi and Ararat seems to consist of Micocene limestone, particularly the region E. S. of Bayazid in the Gedargan Mountain, and the Valleys of Maku, Tanali and Zangimar. The Miocene area has been considerably extended in Turkish Armenia. It is particularly well exposed in the cliffs of Lake Van.

In the upper part of the Frat Valley is described the highly fossiliferous Micocene limestone of Kardarich, a few miles above Ashkala. Here the Erzerum plain is closed in on the west by a wall of limestone through which the river has cut a sharp ravine.

UPPER MIOCENE. SARMATIAN. In the region of the Central Caucasus the Sarmartian deposits are the earliest representatives of the Miocene and occur in notable transgression of Palaeogenic deposits. Isolated fish scales are usually the only fossils that occur in the Upper Miocene of the Armenian plateau. At Nakhichevan are found the fishes *Clupea lanceolata, and C. humilis,* in the thick red, yellow and light colored Sarmatian marls, which are nearly always unfossiliferous, and enclose gypsum and rock salt. Near Julfa, lower down the Araxes Sarmatian saliferous marls discordantly overlie the uplifted Eocene beds of Dary Mountain, and include *Pecten sarmaticus, P. Hopkinsi.* At Yaija lower down the Araxes, simalar saliferous marls form a plain between the Devil and Itushem Mountains. The Saliferous marls are extensively developed in Azerbaijan,

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especially in the Valley of the Aji River, on which Tabriz is situated. The saliferous series is widely distrbuted in the basin of the Tortum and Olti Rivers, and also in the Valley of the Lower Chorokh below Ispir. Rock salt is quarried around here. Broad Frat Valley between the Lower Miocene limestone heights of Pirnakapan and Ashkala is occupied by clays with thick seams of white gypsum. The saliferous series is extremely developed to the W. and S. W. of Erzinjan and S. of Erzerum where salt pans occur. Some saliferous marls occur on the S. side of the Taurus with the same salt pans.

PLIOCENE. The Pliocene fauna of Maragha, on the E. coast of Lake Urmi, consists of the remains of Hipparion, and of Cervus in a trachyte-tuff mixed with earthy gypsum.

The vegetation at the time of Pliocene was luxuriant enough to support mastodons, giraffes and antelopes which could wander unchecked from Greece to Persia. Most of the Pliocene lakes persisted into the Pleistocene and even at the present day several remnants still occur—either of fresh water such as Lakes Gokcha, Chaldir, Toporavan and Nazik, or with varying degrees of salinity such as Lakes Khozapin, Van, Udmi and the small soda lakes southeast of Ararat.

The Pliocene fauna of Maragha, east of Lake Urmi, is very similar to that of Pikermi, and also shows some points of resemblance to the Sivalik fauna. Characteristic are *Palaeohyus maraghanus, Giraffa attica, Palaeoreas Lindermayeri, Tragoceros, Hipparion gracile, Rhinoceros Persiae, Mastodon pentilici, Hyeximia.*

Remains of a similar fauna occur in the bed of the Arpa river at Alexandropol, and indicated at Zokh at the southern base of the Taurus, but this locality still awaits exploration.

PLEISTOCENE. The Pleistocene deposits consist of horiontal or slightly inclined calcareous tuffs, marls and clays, which are often completely filled with *Dreissensia polymorpha.*

The deposits vary in their inter-relationship and arrangement, in almost all exposures, in which they are shown (Melaskert, Khinis, Erzerum, Pasin, Erivan). Where the base of the series is visible it is represented by conglomerate with rocks such as *Vivipara vivipara, Valvata piscinalis, Rissoa, Planorbis,* derived from the neighborhood and contains numerous shells,

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Weritina, Bythinia, Melanopsis, *Unio tumidus*, Anadonta, and Sphaerium, as obtained from various known localities.

The brackish water deposit with *Cardium catillus* is found in the Lori plain (Somkatian) and that with *C. ovatum* at Melik-sherif in the Kelkid Valley. Recent diatomaceous earth is known from Ilija in the plain of Erzerum and at Kissatip in the Uraval Valley near Akalzik. Occasionally in the Dreissenia beds, mammals (*Elephas primigenius*) appear, for example, at Alexandropol and near the junction of the Lori and Debeda. *Elephas armeniacus* is found at Khinis.

The Dreissensia beds are invariably either covered over or interbedded with recent lavas and tuffs; even today there are present the remnants of the ancient lakes either fresh-water, like the Gokcha, Chaldir, Toporaran Tortum, Bulama and Nazik or more or less of saline content as Van, Chosapin, Gojik (with borax), and further the small soda lakes southeastward from Ararat and the Lake Urmi in Persia. The lakes of Gori and Goleh have dried out in historic times. Shrinking of the lakes is often recognizable through old shore lines; as, for example, those observed by Oswald, on the south cast of Lake at 15, 40, and 100 metrs in length and farther in long parallel terraces of Pasin northward from Hassankala and those of the Olti beween Nariman and Id.

In the border ranges, the recent beds are covered by the travertine from lime and iron springs; for example, at Hamsi and Lijera, southward from Trabizond and at Mushoma in the Pambak range. Even now deposits of calcareous tuffs are being made at many springs, for example, at Gugoghlan near Bingol Mountain. Formerly it was developed on a gigantic scale, as in the Khinis plain, along the foot of the Ak Mountain and near Diadin. Undoubtedly the present wells compared with the former ones are but feeble representatives. The extraordinary vast masses of weathered debris in the entire Pontic range still deserve mention.

GLACIAL ACTION.

The former existence of glaciers on the Bingol Mountain is recognized and the evidence for them becomes amplified by observing three distinct moraines which commence at about 2 to

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3 miles from the cliffs of the cirques. The Bingol glacier must have been partially divided near its head by the long, terraced ridges which extend northwards from Karakala.

On the north side of Ararat one small glacier still exists at the head of the great Akhury chasm, descending to as low as altitude of 8,000 feet—a notable fact when we consider that the line of perpetual snow on this side of Ararat is as high as 14,000 feet. On the west side of Ararat a broad ravine cuts deeply into the flanks of the Kippgol cone and is occupied by a quite imposing glacier with very blue banded ice, issuing between high moraines.

In descending to the plain erratic blocks and traversed moraine-hillocks can be noticed between which are innumerable lakes. In several places lavas alternated with moraine debris. Between Igdir and Erivan may be crossed numerous moraines full of obsidian fragments.

Alagoz on the north side of the great mid-Araxes depression has also been the birthplace of glaciers even at the present time. Moraines were noticed also by Frech in the valley of the northern slope of the Gokcha ranges, i. e., at Delyan. The height of Eshak Meidan also show morainic slopes. Numerous traces of glacial action in the region of Chorokh is asserted by Palgrav.

According to Major Mannsell the moraines and glacial lakelets occur on the broad Kashish Mountain (E. of Erzingan) and on the Shaitan Mountain (also about 12,000 feet) W. of Bingol.

In the Taurus short glaciers are known on the Jelu.

B. ANATOLIA.

Tchihatcheff distinguishes in Anatolia two special formations:—"Terrain Indetermines" and "Terrain de Transition." In all cases he uses these collective terms to designate the non-fossiliferous deposits, on account of high metamorphased and dislocated conditions of the rocks. The formation of this nature occur in Devonic, Carboniferous, Jurassic, Cretaceous and in the different stages of Tertiary. They occup very limited spaces and are found separated from one another. The rocks that are not furnished by organic remains are attached to the fossilif-

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erous deposits only by their mineralogical compositions and stratigraphical conditions. The nonfossiliferous rocks are clay slates, mica-schists and talc-schists, which abount in many points of Anatolia, especially in Anti-Taurus and in the surrounding districts of Bosphorus.

At the base of this series comes the formations of granites, syenites and gneiss. The Olympus of Broussa is an intrusive granite formation in the old schists with white marbles. Following the same meridian we find a gneiss at Geordiz, Alachair on the south of Aidin, etc. A very important granite series occur between Yozgat and Nigdé, on the northwest and southwest of Kaiserieh.

Devonic fossils have been found in several places of Anti-Taurus and near the Bosphorus. In the south of the Sea of Marmora a zone of crystalline and schistose rocks of Paleozoic period occurs. There are several other areas of ancient rocks in the western part of Anatolia about which very little is known.

Carboniferous fossils have been found in some localities in Anti-Taurus, in Eregli (Heraclea-Pontica) where they have been worked for coal. Carboniferous fossils also occur in the limestones of Balia-Maden at Mysia.

Triassic, Jurassic and Cretaceous beds form a band south of the Sea of Marmora, probably the continuation of the Mesozoic band of the Black Sea coast. The direction of the folds of this region is from west to east, but on the border of Phrygia and Mysia they meet the northwesterly extension of the Taurus folds and bend around the ancient mass of Lydia. The limestones of Cretaceous age form a large part of the Taurus, the interior zone probably includes the rocks of earlier period. Cretaceous limestones and serpentine rocks take a large part in the formation of well defined mountain system running nearly parallel to the Black Sea coast from Batum to Sinope. West of the Sinope Cretaceous beds form a long strip parallel to the shore line.

The deposits of the Central or Lycaonian plateau consists of fresh water marls and limestones of late Tertiary or Neogene age. Along the southeastern margin, in front of the Taurus stands a line of great volcanoes stretching from Kara-dagh to Argaeus. They are now extinct, but were probably active till

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the close of the Tertiary period. Limestones of Eocene age form a large part of the Taurus. The folding of Anti-Taurus effects the Eocene but not the Miocene, while in the Taurus the Miocene beds have been elevatd, but without much folding, to great height. Marine Eocene beds occur near the Dardanelles, but the Tertiary deposits of this part of Anatolia are mostly freshwater and belong to the upper part of the system. In western Mysia they are much disturbed but in eastern Mysia they are nearly horizontal. They are often accompanied by volcanic rocks, which are mainly andesitic and they commonly lie unconformably upon the older beds.

SILURIAN.—The Silurian is reported only from the district of Bosphorus with the following fossils: *Trochoceras Barrandii, Tentaculites ornatus, Spirifer Pellico* and *Davonsti, Spirifer cristata, Orthis Gervillei* and *basalis, Strophomena rhomboides* and *Bocci Boblayei* etc. All collected by Archaic and Verneuil.

DEVONIAN.—Lower Devonic beds are found in the districts of Bosphorus, forming two isolated strips. In the littoral of Bosphorus they strike S. W. and S. E. The principal rocks of Lower Devonic formations are limestones and clay slates passing gradually into mica-schists. The mica-schists and limestones are equally associated with grits and sometimes with noncrystalline quartz. The Devonic beds of Anatolia look poor in fauna when it is compared with America and Europe. But, yet it is very well developed when it is compared with the fauna of Carbonic age of the Anatolia. The Devonic fauna is specially concentrated in the blue limestones of Kanlidja-Kov (Bosphorus) where *Homalonotus Gervillei* and *longicaudatus, Vern; Spirifer subspeciosus; S. Verneuili,* Murch; *S. Triger,* Vern. *Orthis orbicularis,* Arch.; *O. Trigeri; O. Beaumonti,* Vern; *O. devonica,* Orb.; *Leploena,* ind.; *Chonetes Boblayei,* Vern.; *C. sarcinulata; Autopora tuboe-formis,* Goldf.; *Pleuro dyctium problamaticium,* Goldf.; *Constinopolitanum,* F. Roem, fossils are identified.

Upper Devonic beds are reported from the southern littoral, between Selefké and Kilindria, and from the Anti-Taurus. The beds in Karapounar-Dagh strike N. W.; in Tchatal-Oghlou, Karakov, Baghchejik and Yerebakan strike S. E.; in the dis-

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tricts from Feké to Hadjin, strike W. or S. W.. The principal rocks are white and blue limestones, alternating with dark schists or yellow marns. The Upper Devonic system of Anti-Taurus is similar in minrealogy and stratigraphy to the Lower Devonic of Bosphorus. Only the vertical redressment of the beds and the discordance between their elongation is more frequent in the Upper Devonian. The characteristic fossils found in Tchatal-Oghlou: *Rynchonella Boloniensis,* Orb.; *Atrypa reticularis,* L.; *Spirifer Verneuili,* Murch.; *S. Pellico,* Arch. and Vern.; *Orthis striatula,* Schlot.; *Productus subaculeatus,* Murch.; *Cyatophyllum quadrigeminum,* Goldf.; *C. cespitosum,* Goldf.; *Campophyllum, asiaticum,* M. Edw. and Haime.; *Favosites cervicornis,* Blainv.; *Alveolites suborbicularis,* Lam.; *Stromatopora polymorpha,* Goldf. The same fauna is also identified in the blue limsetones of Feké with the following extra fossils:— *Spirifer Trigeri,* Vern.; *S. Seminoi,* Vern.; *Chonotes nana,* Vern.; *Productus Murchison,* Kon.; *Fenestella antigua,* Goldf.; *Cyotophyllum Marmini,* M. Edw. and J. H. *Favosites Tchihatcheff,* J. Haime.; *F. reticulata,* Blainv.; *Alveolites suboequalis,* M. Edw. and J. H.; *Coenites fruticosus,* Stein.

In the Devonic fossiliferous rocks of the Bosphorus is found iron and copper pyrite; in the transition system of the same age is found corondum associated with titaniferous iron, argentiferour galena, lead, iron etc.

CARBONIFEROUS.—Carboniferous beds are reported from the northern littoral of Anatolia, between Heraclea (Culm or Yordale beds) and Amasry, and from the Anti-Taurus. The Carbonic is found in the same region as the Devonic, they strike mostly S. W. and conform the Devonic deposits of Bosphorus and Anti-Taurus, with a direction of S. E. and N. W. The Carboniferous system of Anatola is represented by limestones formations and coal measures. The coal belongs to *Middle Carboniferous Coal measures* and the limestone belongs to *Lower Carboniferous Marine formation.* These are some isolated members of the long chain of Carboniferous system of Europe and America. The coal and the limestones are concentrated in the same direction. The coal deposits are more in northern sections of Anatolia than in the southern districts. The Lower Carboniferous Marine formations are much more

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developed than the Coal Measures. This shows that the coal is rarely continued in the limestones. To the limestones of Carbonic age joins clay slates and grits in different talcous rocks, specially in great strata of mica-schists, sometimes alternating with one another and sametimes forming a considerable separate mass. The beds of Carbonic age are often strongly redressed, folded, dislocated, and disposed in the anti-clinal or synclinal series, as in Ilkas-Dagh, in the district of Yeni-Khan, along the Lake Beishehr, between Yailaji and Hadjin, etc.

The Carbonic age of Anatolia is very poor in fauna and flora. From this consideration it may be said the conditions prevailed in Carbonic age has not been favorable for the development of organic life. Schlehan has identified, in the district of Amasry, the *Strophomena antiquata, Strophomena aculeata.* Fischer has identified the *Harmodites radians* (*Syringopora reticulata,* Goldf., *Syringopora catenata,* J. Morris). The *Strophomena antiquata,* Br. (*Productus semireticulatus,* Mart.) is exclusively carbonic, but the *Strophomena aculeata,* Br. (*Productus horridus,* Sow.) is probably Permian.

The exploitable mineral substances are concentrated in the transition system of Carbonic age.

PERMIAN.—The Permian is not known anywhere else, but in the transition system of Amasry district by the *Strophomena aculeata,* Br. and *Productus horridus,* Sow. fossils.

TRIASSIC.—The Triassic croppings are not very well known in Anatolia. Only in the northwestern part of peninsula, this formation appears with increasing frequency towards the Eastern Alps. This fact reveals to us a sea extending from the interior of Asia over the south of Europe. It is this sea which the study of the distribution disclosed to Neumayer, and it has been named by him the *"Central Mediterranean."*

JURASSIC.—The Jurassic is reported to form three strips situated in the southwest of Angora, in the south of Boli, and in the littoral of Paphlagonia, in the district of Amasry. All these strips are composed of limestones and marnous rocks, and the whole formation is characterized by a considerable redressment of beds. The predominating directions are S. W.-N. E. and N. W. -S. E. with a local oscillation from north to south. The Jurassic fossils in Anatolia are not very abundant.

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In the calcareous rocks of Angora district are found the fragments and imprints of Ammonites among which are *Ammonites tortisulcatis,* Orb., *Ammonites arduennensis,* Orb.,*Ammonites plicatilis,* Sow., and *Ammonites tarticus,* Pusch.

These facies are sufficient to arrange the formation of Cephalopodes, in the Oxfordian Stage. The absence of these facies in the Amasry formations indicates more recent stage, probably Kimmeridgian or Portlandian which is comparatively poor in Ammonites. In all cases it is probable that the Jurassic formations of Anatolia are of same age as the formations of Crimea and European Russia where Jurassic deposits are not newer than Coral-rag, and not older than the Kelloway-rocks.

CREACEOUS.—The Lower Cretaceous beds do not exist in Anatolia. The Upper Cretaceous is rested upon the Transition. The Creaceous system of Anatolia is identified by the white and tufa chalf formations. The white chalk is very well developed in the Abdi-Pasha, Ekhty-Oghlou, Bithynia, Amasia, Pontus, Cilicia, etc., all containing Cycloites in the vicinity of *Cyclolites Cancellata.* The tufa chalk is only represented by a short deposit situated between Kizilja Punar and Heraclea formng an isolated mass in between the two white chalk formations. The Cretaceous formations extend in two directions—N. E. S. W. and N. W. The formation existing between Kizilja-Punar and Heraclea represent the oldest tufa chalk in the peninsula. Both white and tufa chalk beds have very normal physiognomy, are generally composed of white marnous limestones, horizontally stratified, and, in some regions, considerably modified by the action of eruptive rocks. The eruptive action has sometimes been anterior and sometimes posterior to chalk deposits. The metals derived from eruptive rocks are replaced by limestones. The aspects of Grauwake, due to the eruptive action is found in the district of Amassia and Tokat, as an equivalent to the porphyritic detritus formation of the Caucasus. The Cretaceous rocks of Anatolia are very poor in fossils. In calcareous series, associated with sandstone, between Akché-Ova and Abdi-Pasha are found the following fossils:—*Ammonites varians,* Sow., *Acmoea* ind., *Terebratula semiglobosa,* Sow., *Inoceranus Lamarkii,* Sow., *Ananchytus ovata,* Lamk., *Pentacrinites,* ind., *Scyphia* indetermined.

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Among the compact sandstones existing near Kizilja Punar the following fossils are noticed:—*Terebratula desparilis,* Orb., *quadricostatus,* Sow., *Pecten* ind., *Inoceranus Lamarkii,* Brong., *Alveolina* near *A. cretacea,* Arch., etc. The chains of Amasia and Tokat are characterized by Hippurites.—*Hippurites cornu-vaccinum.*

EOCENE.—The Eocene formations of Anatolia surrounding the older rocks begin with sandstones, conglomerates, and clays, which become calcareous and nummulitic upwards, and then change again to unfossiliferous sandstones and shales with subordinate lacustrine beds. These strata are much disturbed and faulted and are often vertical. The deposits of this nature are wide spread, forming entirely separate and large patches in the opposite directions of the peninsula; in Mysia, Lydia on the west; in Pisidia, Lycia, Isauria and Cilicia on the south; in Paphlagonia, Galatia and Bithynia on the north.

The Eocene of this country does not seem to contain a considerable lacustrine deposits, all mostly being of pelagic origin. From the facies and other stratigraphic considerations the Eocene system belongs to the grand type of *Asiatico Mediterranean* according to Archaic. This system is characterized by the rich fauna of Rhizopodes and of the generas of Nummulites. Fossils:—*Terebellum convulatum,* Lmk., *Corbis lamellosa,* Lmk., *Cardium hybridum,* Desh., *Lucina gigantea,* Desh *Ostera rarilanella,* Millev., *Nummulites biaritzensis, Nummulites perforata, Nummulites exponens, Alveolina ovoidea, Operculina grannlosa, Orbitoides dispansa.* In two places in the vicinity of Angora, the gypsums and sandstones alternating with white marns contain *Certhium Tchihatcheff* and an *Ostraca parisensis,* in Yozgat, the sandstones, are characterized by *Alveolines.* The Eocene deposits look rarely intercolated directly in the Miocene, but mostly underlaid the lacustrine deposits which are probably Pliocene.

OLIGOCENE.—The Oligocene is only identified in the district surrounding the Dardanelles where immediately overlying the Nummulitic rocks is a succession of lacustrine sandstones, clays, and shales, interstratified with volcanic rocks and containing coal seams. This formation is identified by the fossil *Anthracotherium,* nearly related to *A. Minus* as evidence of its stage.

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Prof. Toula, in 1895 found remains of *Chrysodium* (Fortisia) *Lanzaeanum*. He moreover identified *Sterculia Labrusca*. These plant remains occur between Kara-Deré and Boz Borum, in two marl beds, in a series of sandstones with layers of conglomerates and slaty marl, dipping 45° north-northwestward. At Keshan a thin fossiliferous seam contains abundant casts of *Corbicula* (*Cyrena*) *semistriata* and *Melanopsis* aff. *Melanopsis fusiformis*, accompanied by plant impressions. From the abundance of *Corbicula semistriata* it is certain that the coal seams in the Dardanelles districts is Oligocene.

The Lower Tertiary volcanic rocks show a marked tendency to appear along the coast of the Eocene Sea, and in long belts following the strike of the foldings of the Lower Tertiary strata. The wide spread late Eocene and Oligocene volcanic rocks would certainly seem to imply considerable differences in the relief of the land, at the time at which they were ejected and is difficult to reconcile this with the equally wide spread coal seams, presumably requiring shallow lake or marshy country with only slight differences of level.

MIOCENE.—The Miocene of Anatolia is known to exist in the districts of Cilicia, Lydia, Caria and Troad. They are deposited in the sea bordering these regions. The rocks of Miocene age are white or yellow limestones (silicious, amorphous, and crystalline), conglomerates, marns, and gypsums. Rocks are horizontally disposed, and rested upon the Lower Tertiary and sometimes upon the transition. They are sometimes competely exposed and sometimes covered by recent lacustrine sediments.

The existence of the Helvetian.—Tortonian deposits between the Ponto-Caspian and Mediterranean is proposed by J. English. These are overlain by fresh water Sarmatic strata with Lignite and Naptha, successively marine *Mactra Limestones*, which occupy nearly the whole of the northern shore of the Sea of Marmora, to the exclusion of Levantine Beds suggested by F. Von Hochstetter, as filling up this area. These *Moctra Limestones* are in direct continuation with those already known in the southern Troad and in Dardanelles. At Heraclea occurs an expossure of sands and sandy limestones, with a slight southerly dip. These beds, close to the present sea level at Eregli, contain typical

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Helvetian-Tortonian fossils—*Pecten aduncus, Alectryonia Virleti,* and *Anadora diluvii,* also *Ostrea lamillosa.* Near Myriophyto, on the southern shore of the Sea of Marmora, a band, full of *Ostrea crassissima* occurs under soft yellow sand, dipping about 45° S.-S. E. 700 feet below sea level. Heraclea and Myriophyto Lower Miocene marn shell beds, thus formed links in a chain of deposits of the same age, extending from the Crimea to the Mediterranean; they are detached fragments of a continuous sea-beds.

The rocks of Sarmatic stage of the Miocene is well exposed at Evenkovi (Troad) which now known to border the western coast of Trojan Plain, beyond the mouth of the Touzla, near the promontory of Baba-Burnou. At the site of the ancient Hamaxitos, the Mactra-Kalk occurs with its characteristic fossils from the Acropolis. This limestone is undoubtedly marine origin. Beneath the limestone is a great thickness of sand and clay beds, which are underlain by a conglomerate and probably, at the bottom of the series, by a stratum of red clay. The conglomerate chiefly composed of Andesites and Liperites. All organic remains indicates that the strata belong to the Sarmatic stage. The marine beds which overlie the *Mactra-Kalk* are largely developed south of the mouth of the Touzla, and contain great number of fossils, among which are many Ostreae and Gastropods. The fresh water series occupies a large part of the interior of the Troad, about the great plain of Menderé, between Eanedeh and Bairarmitch, as well as along the southern coast, west of Papazly. According to Prof. Neumayer it must be Upper Miocene, Mio-Pliocene or Lower Pliocene, from the determinations of fossils. Numerous oscillation of the land, as indicated by the varying character of strata, must have occurred during the Miocene and Pliocene periods. In all probability these movements were connected with the extrusion of the eruptive rocks so abundant in the region.

Middle Tertiary has been an epoch of the formation of salt beds which are very abundant in Anatolia. Most of Miocene formation are pelagic origin containing in general—*Cerithium modosoplicatum,* Horn., *Fragilia fragilis,* L., *Cardium plicatum,* Eichw. (*C. gracile, Pusch.*) and *Cardium obselatum,* Eichw C. *protractum,* id., *C. lithopodolicum,* Dub.). Among these the

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last two are the characteristic evidence of Sarmatic stage.

PLIOCENE.—Past Sarmatic eastward extension of the central fold of Tertiary rock resulted in the upheaval of the Dahan-Aslan and Serian-Tepé ridge in the district surrounding the Dardanelles. This upheaval closed the connection between the Marmora basin and the Gulf of Xeros, by the formation of a dam, which though much weathered down, is still 180 ft. above the present water level. The dam thus formed was the proximite cause of the cutting of the Bosphorus and of drainage of Marmora into the Black Sea, during Pliocene times. The conglomerate rocks, upon which Galipoli is built, consists in great part of shells of *Didacua crossa, Dreissensia Tschandae,* and *Dreissensia polimorpha.* Prof. Andrussov considers the Gallipoli conglomerate to be the equivalent of the Tchandas beds at Kertch, containing *Dreissensia polymorpha, Dreissensia Tchaudae, Cardium crossum, Cardium Cazecal and Cardium Tchaudae,* which he shows to be an Upper Pliocene fauna of Caspian type, deposited in an enclosed brackish lake before the Dardanelles were in existence. In general the Pliocne marine and lacustrine deposits of Anatolia are found in the Constantinople district, in the regions surrounding the Dardanelles in the littoral of Sinope, in the Meandre Valley and in the Melik-Sherif district with *Cardium edule, Cardium protractum, Cardium Ovatum,* Desh. *Cardium gracile,* and *Mactra deltoides* near the *Mactra triangula,* from which *Cardium edule* and *Mactra triangula* are the best characteristic fossils of the Pliocene age.

PLEISTOCENE.—In several places along the shore line of the Sea of Marmora is found a loamy clay surface deposits, containing scattered shells of Mediterranean facies, at the heights from 10-100 feet above the water. On the top of a law-coast-cliff west of Gallipoli, there has been found a deposit of sand with *Ostrea edulis, Osilium turbinatis, Gibbula adriatic* and *Gibbula Biasolleti* at about 40 feet above the sea level. About a mile further west, on top of a cliff 90-100 feet high, formed of Sarmatic clay and marley limestone, is found a scattered surface deposits of *Cerastoderma edule, Pullastra pullastra, Tapes* cf. *Dianae, Murex trunculus, Murex Brandaris, Cerithium vulgaturi, Loripes lactens;* and *Petricola lithophya, Didacna crossa* and *Dreissensia polymorpha* were also found probably derived

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from Gallipoli conglomerates.

GLACIAL PERIOD.—The Glacial action has been proved in this classic country by the existence of a considerable number of lacustrine lakes and by the striated angular boulders in the red loamy clays, dug in Roumeli-Hissar (Constantinople). Calvert has also found boulders and clays in the Dardanelles Valley, apparently distributed along an old beach from the foot of Kemel to the Five Pines, also large blocks of quartz, some of them situated in the ancient river-gravels of Rhodius 50-60 feet above the present level. This quartz block must have come from the auriferous reef at Astyra, about 12 miles distant to the east-southeast.

GEOLOGICAL HISTORY.

Too little is known at the present time concerning the stratigraphic position of the pre-Devonian metamorphic schists. So that we cannot assign the period of the foldings. Until it is more definitely known we can assume that the S. W.-N. E. extending folds, in the crystalline schist of Taurus, in the marbles and schists of the Kisilja Mountain, Shatin Mountain, Akh Mountain and of Dersim in the centre of the plateau, as well as those in the smaller outcrops of metamorphic rocks, in the northern and eastern border ranges, in Artvin and Ardanush Valley in the Pontic Region, in the Meschic horst, in Somkatian Mountains, in the region of Daralagoz and the Karabagh were caused by the Caladonic Mountain building. In all these regions northeastern-southwestern strikes are universal. It appears that the land surface has been broken into separate blocks after folding, which for the most part sank down at the base of the geosyncline of the Devonic Sea.

The Devonian is at present known only from eastern Armenia; but the sea of this period evidently stretched on interruptedly toward the westward into Asia Minor, for in Araxes Channel and in Antitaurus the succession of formations and the facies of the Middle and Upper Devonic are identical. The calceola limestone following upon sandstones and the conglomerates are evidences of the transgression of the Devonic Sea which soon developed such a rich coral and Brachiopod fauna.

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With the end of the Devonic no alteration occurred in the physical relationship. Without interruption the coralline limestones continued until the Middle of the Upper Carbonic (Moscow formation). At this time the sea became more shallow as may be inferred from the appearance of Fusilinas, Bryozoas, and Calcareous aglae. At the end of this period, according to Frech, a strong folding took place running through N. W.-S. E. direction. According to Bonnet no folding took place in Armenia at this time. And the Permo-Triassic lies wholly concordantly upon the preceding beds even implying a deepening of the sea.

Shales of the Upper Permic and the Lower Triassic are known only from the region of Julfa, on the Araxes and the Kasanyaila Mountain. We have to do here, probably, with sedimentation in an eastern gulf of that sea which stretches from the Indian salt chain through Persia, entering then into Armenia under the dominion of a period with contniental conditions. Probably it stood in close connection or relation with the old Pontic tableland which at some time formed a half island of the western arctic peninsula. Also at this time the Central Caucasus was raised; for there Liassic shales lie discordantly over Palaeozoic shales with the Calamites and Syringodendron.

Recently the existence of the Triassic sea in the Crimea western Caucasus and in Western Anatolia have been proved. Crustal movements continued through Post-Triassic time, but the Julfa bed of Araxes region and of the northern Persia only show flaxures. Armenia seems to have remained a part of a stableland whose eastern coast was washed by the Liassic and Dogger Sea, which towards Persia became deeper. Only the eastern border of Armenia seems to have been touched by the transgression known from Dobrusha and Mangishlak, which spread from Bajocian to the Callovian epoch. Remains of the plants and the elastic character of the Bajocian sediments points to the close proximity of the coast. After a small regression in the Oxfordian and Sequanish the Kimmeridgian transgression started strongly in the region of Karabagh as well as Debrusha and Libanan. In the eastern part of Armenia clear proofs of Tithonian regressions are found and in one region which extends from the Meschic horst southward to eastern Karabagh,

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began a pre-Tithonian folding from the south, which preceded the volcanic activity. And as a result of this folding a large part of Armenia and of Caucasus rose up over the sea level. The fresh water deposit of the Purbeck, and the brown coal beds of Migri (western Karabagh) prove the dominance of contiental conditions.

In the eastern border range there exists a pronounced gap between the Kimmeridgian and the lower Cretacic. This regression is continued still longer in the region of Lake Urmi, where Callovian overlain by the Hauterivian tuff.

The broad transgression of the Middle Cretacic makes itself felt also in Armenia. At Gerjer, just south from Jufa, on the Araxes lies a carbonic. The Cenomanian (Caprotinen) limestones of the eastern border range which agrees with the Mediterranean are separated from the north Armenia. In Caucasian and Pontic Cenomanian limestones the central European facies dominates. The facial difference of the two regions holds also in the Upper Cretacic. At the east of the Urgonian they seem to have been separated by a neck of land. This extended over the Somkatian Mountain range, which still to-day consists partly of crystalline schist, which except in the Valley of Bolnis, where they are overlain only by Hippurites, limestones, are covered by no younger sediments. Further to the south in the Pambak and Gotcha ranges another part of the shale continent had remained stable until it was flooded by the Turonian sea. In the Turonian still existed the Somkatian land barrier as facies limit. Turanian Hippurites limestones stretched with interruption from Karabagh along the cliff of Shatin Mountain to the Frat. These Hippurites are found as recently shown also in the northern slope of the Pontic Range and of the Taurus. During the Cenonian there seems in opposition to this, i. e., to have existed extending west and south of land somewhere from Batum to Ararat, for littoral sediments with the detritus of syncroneous volcanoes are found along the eastern border of this zone. Southward from Batum there cannot have been land; for on the northern slope of the Pontic range there is Cenonian, which is lacking, however, southward of this range to the northern border of the Taurus, where the Mediterranean Hippurites facies of the Cenonian is well known.

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The upper Cenonian of Eastern Karabagh shows that the sea toward the northeast to Daghistan became deeper. Because of the general clastic character of the lower Eocene in the north, northeast and south and its content of brown coal, it is more than probable that at the beginning of the Tertiary most of Central Armenia was land. The red sandstones and conglomerates are plainly products of weathering of a land, long exposed above sea-level, along the borders of which coals developed in delta marshes. The negative movement agrees with that of the regression, which is so characteristic for the geosynclinal zone, the Alpine region. Beginning at this time during the course of Tertiary, Armenia became from a continental region or region on the border of a geosynclinal zone extending from Europe to Asia. The beds beginning with Nummulites perforatus, typical for the Middle Eocene of the Alpine, geosynclines are noticeable in the Tigris basin and in the Zagros Chain. The above named beds lie mostly upon Turonian, in places even on palaeozoics, and began with great red colored conglomerates. Their fauna is very rich. The sea in which they were deposited was warm and favorable for the development of numerous and manifold Nummuliths. In the Pontic region the volcanic activity which had begun in the Cretaceous with the formation of rhyolites and dacites reached its maximum in the Eocene. Lava streams of hornblende and augite-andesites basalt and the tuffs of these spread over the sea bottom. The thin limestone banks interbedded with the volcanic rocks are poor in fuana because of the unfavorable conditions of animal growth. During the Upper Eocene the Antitauric folding was evident in South Armenia and in the Karabagh, so that an extensive part of the Armenia again became main land.

The Flysch facies of the Upper Eocene, with fish scales and activity is exhibited strongly in the north (Akalzik and Kur basin) and less distinctly in the west Karabagh. Between Hipsala and Kisbeli these Flysch facies appear again in the outermost part of West Armenia.

In the beginning of the Oligocene the old Somketian land bar region was widespread. It completely separates the Caucasian sea, with its central European and Arabian character (Akalzik basin) from the coral limes of the Daralagoz, with its Castel-

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Gomberto facies extending into Persia. Littoral aqueous deposits and land plants have been discovered on the border of the Armenian land of that time at Argachi (Northwest of Ararat) and at Platana on the Black Sea. They show relation to the Cilician Oligocene with Sotska facies. The post-Oligocene folding which appears in the Cilicia also raised the Oligocene region of the North Armenia, but does not seem to have influenced the coral line of Daralagoz which is overlain conformably by Lower Eocene.

The Miocene of Armenia begins in general with a coarse conglomerate which shows a most widespread transgression in this region. The Palaoezoic plateau of Urmi and Maku (southwest of Ararat) which were dry during the Mesozoic sank into the Miocene Mediterranean, the north coast of which extends in littoral detritus at the foot of the Neocomian heights along the north of the Frat of Sipikor (norh or Ersinjan) to the east through Kop Mountain. The purity shown by the Miocene (Helvetian and Tortorian) coral and Lithothamnian lime, is over. And the lack of flaviatile deposit indicates that the Anti-tauric folding had almost been worn to a peneplain. The detrital deposits of the Upper Eocene and Oligocene were derived from the energetic denudation in the region of this land.

Immediately after the Lower Tortonian a period of folding began, syncronous with that of the Alpine which laid the Miocene chalks into folds. The character of the folding was various in different parts of the land while the Miocene at Bayazid in the west at Arabkir and Kisheli, it is still horizontal. In the latter case the lack of folding can be attributed to the great resistance of the old mass. Further west, the Miocene limestones massed between the Tauric horst and the Syrian plateau, again show folding, as at Killis, Argona and Mardin. At the same time in this Middle Miocene there were mighty intrusions of ultra-basalt rocks which for the greater part have been serpentinized.

In the Sarmatian epoch a continuous aridity followed and desert conditions prevailed. Then the formation of red sandstone and conglomerate (often from serpentine components) and of clays (often with great gypsum and rock salt veins) ended. Then fresh-water conditions began; for example at

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Khoi and Tabris in Persia. The folding continued during this heterogenous Sarmatian epoch. Abich has observed two breaks in this series at Khoi. Beds of this age extended in a broad zone through northern and southern Armenia. In the south the "gypsum" bearing series forms a border at the Zagros and Taurus, in the north of the Sarmatian formation stretches from the northern border chain to the Caucasus and from the Black to Caspian sea. While the beds thrown southward on the southern slopes of Caucasus are overturned toward the north in the Thrialetic chain. Between these two regions in the Mechic horst they lie horizontal and undisturbed.

After this epoch there is no more folding in Armenia. The Middle Pliocene, lacustnrie tuffs of Maragha and Alexandropol lie horizontal with their interesting vertebrate faunas. The continuous elevation of the land gave the Armenian highland their plateau character in the end and were accompanied by shattering, raising and sinking of great blocks. These processes began in the lower Pliocene. It is shown by the forceful earthquakes in the graben that it has not come to an end.

The Pleistocene sea deposits are widespread in the Central plateau. The shells of Dreissensia polymarpha are often found forming beds. These late formations also show no faulting but lie rather horizontal or with a dip of 2-3 degrees. They are in great measure covered by lava sheets which have either been extended from fissures or have been poured from colossal volcanoes (Ararat, Alagoz, Sipan, Nimrud, Samsar, etc.) and smaller pistules arranged in rows (Soganly, Alaja, etc.) The still existing great lakes are partly salt (Lake Chosapin) partly fresh (Gokcha and Chaldir). Absence of Dreissensia polymorpha suggests that there has been a change in physical conditions, as already ascertained. The last voncanic eruption of the Nimrud was in 1441. Tendurek is still in solphatara condition.

2. Anatolia

No obsevations have yet been made to accertain the Primary (Pre-Devonic) formations of Anatolia. Although the old gneiss and granite series admitted to be formed before the Transition, but, yet, in same places, specially in Lycaonia and Galatia, the granites reveal a comparatively recent origin; and some gneissic

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rocks, specilly developed in western Anatolia, pass gradually into clay slates and calcareous rocks characterized by Devonic fossils.

During the long period of Transition only five fossiliferous islets had been formed in Anatolia. Of these three belonging to Devonian are known to exist to-day in the districts of Bosphorus, Southern Cilicia, and Anti Tourus. These three insular groups, being emerged during the Devonian, have all gone through the subsequent periods, while the non-fossiliferous beds belonging to "Terrain de Transition Inditerminés," have never been lifted until Middle Tertiary.

The Devonic beds are often disturbed and they exhibit peculiar stratigraphic divergencies. They are characterized by the same paleontological richness and variety as the European and American formations. But, meanwhile the Devonic system of Anatolia should not be considered poor either in fauna or flora. Various species of Crustaceans, Moluscs, Bryazoas, Annelids, Radiarians and Polyps Abound in these districts.

From the five islets formed during the Transition, the last two belongs to Carboniferous which are known to exist to-day in Anti Taurus and in the littoral of Black Sea. These islets being also emerged during the Devonian, have gone through the subsequent periods. Carboniferous beds are also often disturbed and they show the same peculiar stratigraphic divergeneus. But Carboniferous system of Anatolia is very poor in fauna and flora; the pelagic conditions and volcanic activities during this period have been inimical for the development of organc life.

From the Carboniferous to the Middle Jurassic, Anatolia is represented only by the islets of "Terrain de Transition," because, these islets show very slight vestiges of the Permian, Triassic and Lower Jurassic deposits. During the Middle Jurassic Anatolia has recevied some representative locations and has developed the stage of Oxfordian directly upon the Transition system.

The Jurassic and Cretaceous formations are, same way, imperfectly developed in Anatolia. The Cretaceous period is identified by white and tufa chalk formations. The beds show a great variety, from the normal disposition to the most violent redressment. This phenomena is due to the eruptive actions of serpentine, trachyte, pyroxene and porphyry. Igneous activity is

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much more pronounced in this period and dislocated the beds all the way through the Devonic, Carboniferous and Jurassic. The most characteristic Cretaceous formations are found to day in the littoral of Black Sea. Since the upheaval of this littoral band, it is not subjected to immersion of any long duration, and in no point it is covered by the sediments of any subsequent periods. From this point of view, during the Cretaceous, the Black Sea, without any communication with Mediterranean Sea, was occupying an immense area, extending up to Baltic Sea in cross of Podolia, Volhynia, and eastern Prussia on the north, Lake Aral on the east, and Asia Minor on the south. According to Prof. Oscar Fraa's observations in Syria, the Cretaceous mountains surrounding the littoral, have never been subjected to immersion after their upheaval. So that, certain points in northern Asia Minor, had already drawn limit, since the Cretaceous, on the southern littoral of the Black Sea. Same way the eastern borders of the Mediterranean was already marked by certain mountain chains on the Syrian coast, at this time.

The eminently insular character which Anatolia conserved up to the formation of chalk, never disappeared until Lower Tertiary. At this time the Cretaceous band of northern littoral with many islands of Transition, had been disseminated upon the surface of the peninsula and connected with vast deposits of Lower Tertiary of eastern Europe. These European deposits are distinguished from the type of "Asiatico-Mediterranean" by its well developed facies of Rhizopodes, through which Asia Minor is to-day, considered as a classic country of Nummulites.

Another system, entirely independent from the Tertiary fossiliferous rocks and entirely barren of organic trace, has been distinctly overlaid by the Nummulitic group. This is the Upper Stage. The most part of the Lower Tertiary of Anatolia have never been subjected to immersion, after its upheaval. Because the majority of the recent formations are exposed, represent indepent deposits, and are placed in considerable distances from the formers.

By the upheaval of Eocene deposits one great part of the Black Sea was lost in the directions of north-west-north and north. In this way it was separated from the Baltic Sea by the emersion of eastern Prussia, and a numerous insular groups ex-

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tended in the southern regions of this sea. These were connected with vast continental surface, like the government of Poltava, Voronéjé, Tombof, Penza, etc. So that, after the emersion of the LowerTertiary deposits, the Black Sea resumed the granitic steppe comprised between the Bong, Dnieper and the coal basin of Donetz. But, the southern, western and eastern limits of this sea have not submitted to a notable modification. After the upheaval of Eeocene deposits, the Black Sea was same way cut off from all communication with the Mediterranean. The Crimea was only existing in a narrow band, rising up as an island, and was connected with the waters of Caspian Sea and the Lake Aral, at the middle of which now, stands up the insular mass of Caucasus.

The Middle Tertiary of Anatolia is represented by the Nummulitic side of the Miocene Sea. The upheaval of this sediments is sometimes operated very slowly, as it may be seen by the vast Miocene deposits of Cilician littoral, and sometimes very violently, specially in the vicinity of eruptive rocks.

The period of Miocene has been the time of rock-salt formation which occur extensively in Anatolia, specially in the Lycaonian plateau. The majority of these deposits are of pelagic origin. Miocene beds, either marine or lacustrine, are poor in fauna and flora. The large continental mass that Asia Minor possessed during this period was imfavorable for the development of organic life. At this period, Anatolia was separated from the Greece but the Cyprus island was yet forming a junction with the Cilicia. This was sunken during Pliocene and reappeared in the Quarternary. A numerous debris of Quarternary fauna is found in Cyprus island without any trace of its separation from the Cilician littoral.

During Miocene the Black Sea acquired a considerable extension on the north. This extension submitted to a diminition of the eastern regions. After the emersion of an insular mass, the plateau of Ust-Urt, this region separated in two basins, which are to-day called, the Caspian and Aral. The emersion of this island accompanied with a depression of the surrounding countries, resulting in the grand Touranian Depression and constituting the tract of Asiatic Continnent.

Sarmatian Sea lost one part of its salinity during Pliacene. In

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different modification of its size it was connected into a estuary basin, where Aralo Caspian type of deposits overlaid upon the Sarmatian. The northern side of Asia Minor continued marking the southern littòral by a vast sheet of brackish water, which penetrated into Eagean Sea and left many traces of its sojourn on the western littoral of the penunsula. During the epoch of Aralo-Caspian, the formation of the Bosphorus and the Dardanelles took place through which the waters of Aralo Caspian penetrated intoEagean Sea.

The limit of soutern littoral of Propontus was already drawn since Lower Teriary and Transition. But the Black Sea had not yet received its northern limit, which appeared after the emersion of Southern Russia with characteristic Aralo-Caspian deposits. Probably the emersian of this side accompanied with many movements of oscillation and resulted in the remarkable redressment of the beds of different regions of which the Crimea was composed.

During the last phases of pliocene period, Asia Minor had received most of its littoral outlines which possess to-day. But the interior of the peninsula was covered by locustrine basins. So the fresh water sediments were predominating in Pliocene. On account of trachytic eruption in the Pliocene a great number of species of marine molluscs are perished in Anatolia. The pulverulent ejections of this eruptive rocks resulted in an enormous beds of tuffs, known as Diatomaceous formation.

ERUPTIVE ROCKS.

Ultra-Basic. Harzburgite. Tauric region (Lake Van), Chorokh zone (Kop Mountain), Central Plateau (Elmalidere, Palandoken, Gugoghlan).

Lherzolite. Gokcha region (Karaman, Katch Bulack), Chorokh zone (Kop Mountain), Central plateau (Khinis Bastok Valley; Alimur).

Limburgite. West Karabagh.

Basic. Hypersthene—Gabbro; Gokcha region (Karaman, Sarialpas).

Hyperstene—Olivine—Gabbro: Central plateau (Elmali-dereh).

Diabase: Gokcha region (Beikaraman); East Karabagh

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(Chirchan, Shalapli), West Karabagh (Katar), Central Plateau (Elmalidere).

Quartz-diabase: Gokcha region (Sarialpas, Kabagtepa).

Bronzite-diabase: East Karabagh (Shalapli).

Hornblende-diabase: Thrialitic region (Arjevan Mts.)

West Karabagh (Migri), Chorokh zone (Sipikor), Central plateau(Palandoken, Shatin Mt.).

Olivine-diabase: Thrialitic region (Keilissi, Koshkaro), (Kiavturatal, Gujarettal), Gokcha region, Murov Mt. Khatch Bulak);East Karabagh (Dumy, Karadagly); Central Karabagh (Basarkent, Algok, West Karabagh (Dorseli, Askelun, Purunti); Central plateau (Dorseli, Askelun purunti); Central plateau (palandoken, Jermik, Sivan).

(a) With ophitic augite. East Karabagh (Shusha, Jamiat) Chasi, Akhbulakh), Central plateau (Akhalkalaki, Elmalidereh, Muradtal).

(b) With subophitic augite; Somkatian region (Akhtala, Algettal), Gokcha region (Maral Mt.), Central Karabagh (Karagol), Central plateau (Akhalkalak, Shubaret, Ani, Palandoken Pasin, Muradtal).

Olivine-Basalt with Granular-Augite.

(a) Olivine basalt. Pontic region (Kurele); Thrialitic region (Borjom); Central Karabagh (Shipkergol); Central plateau (Muradtal- Bularik), Bingol plateau (Bastok Valley, Gugoghlan near Gumgum).

(b) OlivineBronzite-Basalt. Central Karabagh (Gerjusi), Central plateau (Khamur). ....

(c) Olivine-Hornblende-Basalt. Central Karabagh (Gerjusi), Central plateau (Khamur).

(d) Andesitic-Olivine-Basalt: Imeritic region (Sikari), Thrialitic regon (Kentzikaro near Tiflis), Central plateau(Palandoken, Deveh Boyun). Bingol plateau (Tandurek, Tutakh).

Olivine-Basalt-Tuff. Imeritic region. (Abastuman) Thrialitic region (Kentzikaro); Central plateau (Bingol plateau, Sheikh-Orakratar).

Alkaline basalt:

(a) Leucite Tephrite. Pontic Region (Trebisond).

(b) Nepheline Tephrite. Central Karabagh (Gerjusy).

(c) Sodalite Basalt. Thrialitic region (Sanislo).

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MEDIUM ACIDIC. Quartz-Mica Diorite: Pontic region (Meirimandereh (Asforos Valley), Gokcha region (Maratal), West Karabagh (near Migri, Aldara), Chorokh zone (Golviren, Khoshabpunar), Central plateau (near Gopal).

Quartz-Mica-Augite-Diorite; Pontic Region (Meserch, Kasikli), Gokcha region (Agalagan Mt. Syzismadini, Ulutram Shamkhortal), West Karabagh (near Migri), Daralogoz zone (near Karmir Vank), Central plateau (Tunus).

Augite-Diorite: West Karabagh (Aldara).

Mica Porphyrite: Pontic region (near Hamiskoi-Esseli), Gokcha region (Gokcha Mt.) West Karabagh (Chundurtal).

Hornblende Porphyrite: Pontic region (Asfaros Valley), Somkatian region (Lialvar Mt.), East Karabagh Agjeken, West Karabagh (Njuvadi).

Hornblende-Pyroxene-Porphyrite: Pontic Region (Ardasa Bashkilissa, Ostuk, Kesishkoi); Pambak region (Akta in Sangatal).

Pyroxene-porphyhite: Pontic region (near Khertvis), Somkatian (Usunlar, Debedatal), East Karabagh (Dumi), Central Karabagh (Tatev, West Karabagh (Airy Mt. Katar), Central plateau (Tunus, Sor, Adeljivas).

Feldspar Porphyrite: Somkatian region (Akhtala), Gokcha region (Gokcha Mt.), West Karabagh (Katar).

Mica Andesite: Central plateau (Bingol Plateau).

Hornblende Andesite: Pontic region (Trebizond Meirimandereh), Gokcha region (Zinjirli Mt.), Central Karabagh (near Hassan Kala near Kharassan).

Tuff: Pontic region (Ali Meser), Thrialitic region and Gokcha region.

Pyroxene Andesite: Pontic region, Imeritic region, (Okus Mt.), Thrialitic region (Kumis Borjom), East Karabagh (Gergir), Central Karabagh (near Basarkent), Central Plateau (Lori, Ararat, Takjaltu, Soganli, Palandoken, Eyerli, Madrak, Bingol Mt., Alimur Sipan, Lake Nazik).

Tuff: Pontic region (Mesereh Khan, Central plateau (Ararat, Arguri).

Basic Augite Andesite: Pontic region (Esseli Riseh, Batum, etc.), Imeritian (Abestuman), Thrialitic (Khertvis, Aspinsi, Borjom, etc.); Somkatian (Lok); Gokcha (Lake Gokcha); Central

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Karabagh (Tatev, etc.) West Karabagh (Katar); Central plateau (Soganli, Kars, Armutli, Tandurek, Dumli Palandoken etc.).

Tuff: Imeritian, Thrialitic, Somkatic (Lok), Gokcha (Toglaja); East Karabagh, Central Karabagh (Central Karabagh (Sabukh), Central plateau (Palandoken).

Acidic-Augite Andesite: Central Plateau (Kisvag).

Augite-Trachyte: Thrialitic region (Beden), Central plateau (Palandoken, Nimrud, etc.)

PyroxeneTrachyte: Central plateau (Samsar, Karmush).

Hornblende Trachyte: West Karabagh (Chundur), Central plateau (Samsar).

Phonolite: Daralagoz zone (Garni).

Acidic. Muscovite Granite: Central plateau (Chermigan in Pasin).

Granitite: Pontic region (Meirimandereh), Somkatian region (Lok), West Karabagh (near Sadarak); Central plateau (near Gopal).

Hornblende Granite: Pontic region (near Ardasa), West Karabagh (near Ordabad).

Pyroxene-granite: Gokcha region (Dashkessan).

Hornblende-Granite-Porphyry: West Karabagh (Kapujik).

Quartz Porphyry: Thrialitic region, Somkatian region, West Karabagh (Airy Mt., Katar).

Felsitic Porphyry: Somkatic region (Karagaya); Gokcha region (Khatch bulak).

Rhyolite: Thrialitic region (Beden), Gokcha region, East Karabagh; West Karabagh; Central plateau (Kars, Kharput, Polandoken).

Tuff: Pontic region, Thrialitic region Somkatian region, Gokcha region.

Dasite: Pontic region, Gokcha region, East Karabagh, Central Karabagh, West Karabagh, Central plateau (Polandoken).

Anatolia.

Eruptive rocks of Anatolia occupy a considerable area which in no other countries could probably be seen at the same proportion. Among those trachytes, diorites and pyroxene porphyries come first; syenites, granites, serpentines and diorites

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come second, basalts and eurites occupy the third place in importance.

The trachytes represent a particular agglomeration in the western part of the peninsula covering the whole western littoral. This series goes under the Eagean and reappears again forming trachytic islands as Santorin. The trachyte of Anatolia is porous and rich in oligoclase and vitreous feldspar, as the trachytes of Cape Karabouroun, Smyrna, Afion-Karabissar, Mount Argeaus, Nevshehr, Nigdé, Karadagh, etc.

The trachytes of Anatoia exhibit a remarkable phenomena in its topographical distribution having been frequently associated with saline lakes. The vast group of trachyte of Mount Argeaus is not only situated in the vicinity of Touz-Geullu, but it occupies a lake of this nature in its ancient home since the Jivah Geul came into existence at the southern foot of Argeaus. The trachyte cone of Karabounar, is very remarkable by its crater, rising in the middle of a depression covered by the masses of salt.

The trachytes of Anatolia belong to different ages and the duration looks to be from Cretaceous to Upper Tertiary, or perhaps to Upper Quarternary. The trachytes in the regions between Heraclea and Bartan, and between Angora and Mourtad-Sou valley are posterior to Cretaceous; but the trachytes found between Kysbeli and Hipsala, between Bolat and Guné and in the valley of Kastamouni are anterior to Eocene. They are sometimes before and sometimes after the Upper Tertiary lacustrine deposits. Trachytes of Elma-Dagh are before, but the trachytes existing in the vicinity of Smyrna, between the Kebsid and Bagaditch, and in the districts of Kalburdji, etc., are after the Upper Tertiary lacustrine deposits.

The dolerites are very intimately related to the trachytes and pass in one another; as in the regions between Niksar and Seléyailasi, in Koïli Hissar, in Samson, in Ala-Dagh, between Moondoorlu, and in the valley of Alan Sou. The dolerites comprise also same periods beginning from Cretaceous up to Upper Tertiary. The dolerites during Creaceous have disturbed the deposits of Amasia district. They are decidedly anterior to the nummulitic deposits of Samson, to the Miocene deposits of the regions comprised between the Hipsala and Tokat, and to the

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Upper Tertiary lacustrine deposits of Beibazar Valley.

The dolerites together with the trachytes and basalts have effected the rupture of Bosphorus by only one stroke. The nature of eruptive rocks spread over this region, reveals an alternative phase of repose and activity from Lower to Upper Tertiary.

Pyroxene-Porphyries occur particularly in the eastern part of Anatolia in intimate relation with the syenites and granites which have disturbed the Lower Tertiary deposits.

Syenites and granites pass frequently in one another. They are only distinguished mineralogically from each other. Syenite is very extensive in Anatolia. In many points of the country both eruptives are posterior to the Lower Tertiary as the regions comprised between Alizy and Yozgat, where it forms veins traversing the calcareous rocks, in the Bereketli Maden, Utch-Kapou-Dagh, Ak-Dagh-Maden, and between Ala-shehr and Yozgat, etc. The case is same for the majority of the massive syenites surrounding the northeastern border of grand saline district of Lyaconia.

The serpentine rocks occupy only a subordinate position between the other eruptives of Anatolia. Serpentine contains more or less dialage sometimes pikrolith, bronzite, saussurite, etc. Serpentines with dialage are noticed by Tchihatcheff, in the Korkom-Sou, and a link of Hypersthenite in the Geuk-Sou district. In the district of Beldjeis the serpentine rocks are porous and undulated on the surface. The calcareous rocks between Gedjik and Dalaman are subjected to an appreciable modification in contact with the serpentine. The serpentines in the district of Angora form the current itself, while near the Amasia it is intimately associated with the dolerites of Souslou-Ova. The thermal sources of Troad, and igneous phenomena of Lycia have their home in the serpentine.

The stratigraphic action of serpentine upon the sedimentary rocks has very ostensible in Lycia, Pisidia, Aratch (Paphlagonia), in dislocating violently the Lower Tertiary stratified formations.

The eruption of serpentine have taken place in different intervals of time, because alternating activity and repose are noticed in some places. The deposits of Araratch valley is posterior, and the deposits of Kastamounai valley little further, is an-

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terior to Eocene. Same way in the southern Pontus, between Kysbeli and Hipsala, between Hipsala and Khamourli, the serpentine eruption precedes not only the Lower Tertiary, but also the Cretaceous, as in the valley of Euphrates. The rest is probably anterior to the Miocene deposits with a few exceptions, as in Lycia and Khorzoun.

The serpentine of Hadjiman-Yaila is rich in the minerals of iron and copper. In the serpentines found in the vicinity of Boulgar-Dagh exists a deposit of oligiste iron, while in Lycia it contains all the mineral substances. Same way in Anti-Taurus the beds of oligiste iron and red hemitite are found in contrast with the serpentine.

The serpentine eruptive rocks, among others, are recognized the most metalliferous except the syenite which is considered rich in Alunite. The trachytes, dolerites, pyroxene porphyries. eurites, basalts etc., rarely contain the usefully exploitable mineral substances.

The diorite is uniform in its minrealogic composition. It often lies with the basalt, as in Bashkoi (Argeaus), sometimes with pyroxene porphyry, as in Agatch-Bashi, and sometimes pass in the diabase as in Akserai. The diorites belong mostly to Upper Tertiary, marking often the separation of Tertiary from Quarternary.

The Basalts in Anatolia often offer an imperceptible transition to the trachytes and dolerites, as in Argeaus, Valley of Kirmizi-Chai, in between Almous and Yousouf-Oghlou, and do not play an important rôle. They are anterior to the Middle Tertiary, as in the districts of Eschen-Kevi Gediz, and sometimes posterior, as in the Gurun, Manjoulik, etc.

The eurite and the quartzose porphyry, is found often intimately relating to trachytes and basalts. The eurites of Anatolia are unfortunately situated in the middle of a system the age of which is not determined.

The trachytes, dolerites, porphyries, basalts and eurites of Anatolia are sometimes poured out in elastic or pasty condition, or sometimes more or less fluid, both from craters or fissures.

The most recent plutonic manifestations are resulted in the dislocation of volcanic tuffs, the redressment of the trachytic masses posterior to their discharge, and the upheaval of many

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points of the western Thrace and Anatolian peninsula.

Actually, the volcanic tuffs of Anatolia, occupies a wide area, and evidently, related to the most remote geological epoch, containing the living species of lacustrine diatomaceous animals. In spite of their remote age, tuffs exhibit in the disposition of their beds, the most curious example of redressment or folding; as in the tuffs occuring between the Bergama and Deré-Koi, in the districts of Gullé, Bolat, Tchandarlik, Bashbouran Koi, Ezderoun, in between the Biyad and Eski Karahissar, in the Evdjiler valley, where the tuffs alternate with compact trachytes.

If the stratigraphic conditions of volcanic tuffs indicate a recent phenomena, the end of Tertiary or the beginning of Quarternary, then the same conclusion could be drawn for many trachyte eruptions existing to-day. So, the upheaval posterior to the out pouring would be attributed to the anomalous position of certain trachyte masses in the district of Symrna, where the most recent masses, which repose upon the lacustrine deposits, contain *Helix* and *Unio*.

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PART II.

NON-METALLIC MINERALS.

COAL.

The occurence of coal has been reported from a large number of localities. In only one instance has mining been carried on in any manner compatible with the demands of modern consumption. Aside from this, work has been confined to desultory attempts that were scarcely adequate to meet even the limited local requirements. In no case can technical data regarding the extent, depth or persistence of the seams be had. The present contribution will therefore be necessarily limited to an enumeration of the localities at which the fuel is known to exist.

The well defined divisions will be adopted in the classification of the various deposits listed beow.

ANATOLIA.—The north-westernmost projection of Asia Minor immediatey south-east of the Dardanelles, forms part of a district wherein lignite deposits have been worked in a number of localities. The formations of this district can also be traced to the north on the adjoining European coast of the Marmora. The lignite beds occur mostly in Tertiary lacustrine deposits and appear to belong to a zone of transition between the Miocene and the Pliocene. In the Aegean Sea the same grade of coal is found in the island of Mytelene as well as in the island of Lemnos, where it was mined in 1875.

The best known of these deposits is worked at Manjilik. The seam outcrop here for a distance of a Km. They are operated by the owners of the nearby Balia lead mines. The product is used as fuel for an electric power-station feeding the smelters and workings.

Some lignite is also found near Lampsacus, but as yet has not been mined.

In the Troad, lignite is extracted near Edrimid. The fuel is transported to the seaport of Akchai where it is slacked along the water front and sold in small quantities.

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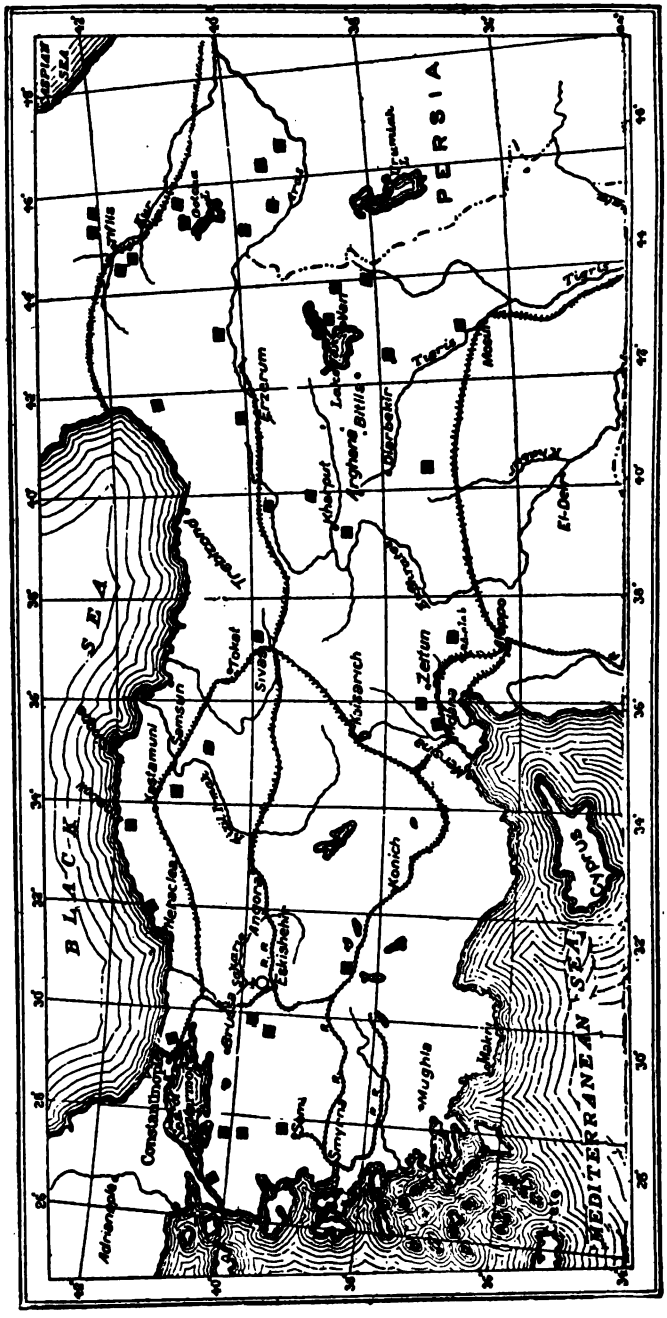

MAP INDICATING THE LOCALITIES OF THE KNOWN COAL DEPOSITS OF ARMENIA AND ANATOLIA.

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Farther south, at a short distance from Soma, the terminal of a branch line from Manissa, a good quantity of this coal has been mined on a small scale.

Near Panderma, at about 4 Km. from Tchamak-dagh, some exploration work was undertaken about 25 years ago in the Mesepsif Valley. The following sequence was determined in this locality.

1. A basal igneous complex, the upper zone of which consisted of a highly siliceous flint-like band of rock averaging 2.5 meters in width.

2. Thick beds of marls with which lignite seams, varying in thickness between 2 to 0.86 meters intercalated. The coal belongs to a high grade lignitic variety. Samples of it gave the following analysis:

Volatile matter 32.6%
Fixed carbon 45.4%
Ash 12.6%

The Tertiary succession in this district is best revealed by the section afforded in the gorge of the Dovantzi river. The basal igneous is overlain by thick beds of tufa, above and lying conformably with which, clayey marl beds occur, with lignite seams about 0.30 m. in thickness.

This series underlies relatively thick strata of bituminous marls. The clay above or below the lignite-bearing strata can be easily detected by large blocks of jasper and chalcedony that stand out from its mass.

West of this region, lignite outcrops are known at Demir-tash, 2 Km. north of Broussa, as well as at Ghemlik.

Mining was also carried on formerly at Tchaideré near Bilejik and at Geuy near Seuyud.

The most easterly extension of this Tertiary lignite is found in the mountains environing Tchai near Afioun Karahissar. Seams have been discovered here at an altitude of 1840 meters, lying over calcareous conglomerates and capper by clay beds. The thickness of the coal attains 2 meters. Practically every one of the above named deposits is susceptible of development in order to supply local requirements.

The southwestern coast of Asia Minor with its hinterland does not appear to be devoid of coal. Seams are known near Makry

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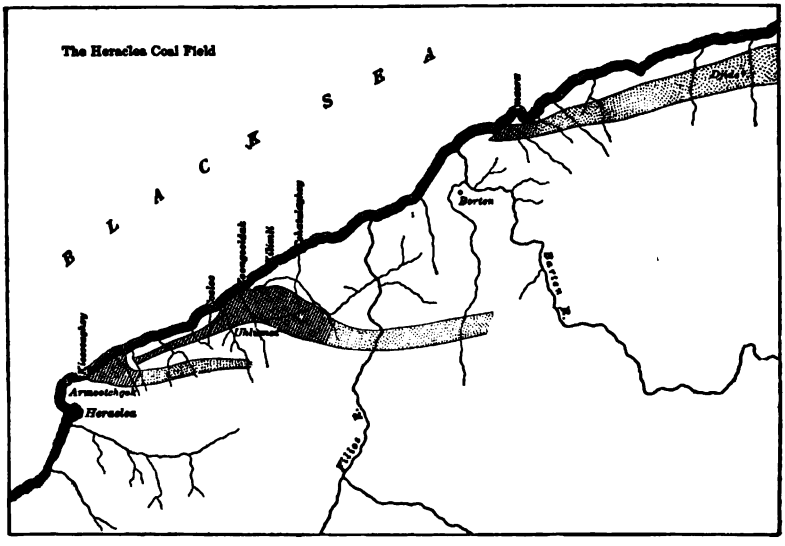
in the foothills of the Eljikdagh Mountain. In the province of Smyrna, lignite beds exist at Gulhissar Milas, Sokia, Aidin, Kiosk, Nazilli, Scala Nuova and Keramos. The Sokia and Nazilli beds have been developed for local use.

The Heraclea coal-field is at present the best developed in Anatolia (See figure). It occupies a belt of about 60 Km. in length along the Asiatic coast of the Black Sea between the seaports of Heraclea and Filios. The Town of Heraclea itself lies at a distance of 135 nautical miles from Constantinople. The coal-beds outcrop near the coast and are known to extend farther than the 8 km. inland. It is believed, however, that they strike



SHADED AREA REPRESENTS KNOWN COAL.
DOTTED AREA REPRESENTS PROBABLE COAL.

south-easterly from the eastern boundary of the district to which mining operations have been confined and that they may be re-encountered at a greater distance from the sea-shore beyond. The coast facing this section of the Black Sea is precipitous. Narrow valleys and ridges parallel each other at right angles to the shore line. The elevation of the land immediately fronting the water does not exceed 60 m. The altitude increases gradu-

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ally southwards until a maximum of 500 m. is attained at a distance of about 3 km. from the coast. Here long chains of hills with a roughly east-west trend, occur.

The stretch of country extending from Heraclea eastwards for a distance of 175 km. along the coast may be considered as a geological province on the basis of the presence of three long and narrow parallel bands of Carboniferous rocks, which comprice Culm, Lower Carboniferous limestones and Upper Carboniferous Coal-Measures. These bands have a general N. 70° E. trend. The country lying between them consists of nodular calcareous beds, chiefly Caprotina limestones.

The unity of the geological sequence appears to have been established by Paleontological as well as lithological data. The strata can be classified as follows in ascending succession:

1. A basal Carboniferous limestone containing Productus giganteous, Syringophyllum and other Polyps.

2. Coal-bearing Measures containing Sphenopteris Baeumleri, Neuropteris gigantea and Neuropteris Schlehani. Above and lying unconformably, the Cretaceous is represented in beds of great thickness by:

3. Greyish crystalline limestone with Requenia gryhoides and Toncasia.

4. A complex of fairly fine-grained, dark colored, clayey and sandy strata.

The correlation of this sequence with the Cretaceous of the Balkans has been established. The latter is itself the prolongation of the Alpine zone on which outcrops of Carboniferous strata appear as at Heraclea. This similarity in the geological relationship prevailing on the southwestern coast of the Black Sea and in a portion of Central Europe, may have a wide significance which does not lie, however, within the scope of these notes.

Differtiation of the fossil flora found at Heraclea leads to a local subdivision into three stages of corresponding to the Culm, Westphalian and Stephanian stages of the European Carboniferous. These are, respectively, the Aladjaaghzy or lower stage, the Cozlou or middle stage, and the Caradon or upper stage. The first two are economically the most important but the best

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coal is derived from the middle stage.

The western boundary of the basin is determined by a long fault line occurring at Kiosseaghzy at a distance of about 10 km. east of Heraclea. The entire measures appear to have sunk in depth at this point. Some coal is won here from narrow seams which can be correlated with the Cozlou stage. The valleys of Kiretchlik, Chaushaghzy and Ilisou appear immediately beyound. Within their limits the Aladjaaghzy series can be first observed. The Cozlou depression lies about 20 km. farther east and is the seat of the widest and most actively exploited veins of the entire district. From this last point the Coal-Measures are detected about 2 km. farther east, to Domooz, where they assume a gradual southerly stike inland. Cutting across the Zoongooldak valley, where their width attains 5 km., they extend beyond Tchatalaghzy valley to Sooksou. Mining ceases at this locality but coal is known to occur as far east as Djidé.

The Aladjaaghzy stage is best represented at the locality bearing that name. The strata appear first at about 0.5 Km. west of the settlement. They have a general east-west strike and dip from 10° to 30° south. Fifteen seams of an average thickness of about 0.75 m. are distinguished by different names. Although they are considered locally as different beds, the profound faulting to which the region has been subjected, subsequently to the formation of the coal, tends to confirm belief in the identity of many of the seams. The uniformity of their structure has helped the unmethodical native to carry on work with relative ease. The same measures have been developed to a less degree, in the valley of Kiretchlik, as well as at Tchaoushaghzy.

A zone of transition between the Aladjaaghzy and the Cozlou measures is revealed by the presence of a number of almost vertical seams. Their thickness is the same as that of seams below. They occur along a double eastwest line of faulting, which also constitutes the southern extremity of the coal-basin, since beyond it, to the south, only Carboniferous limestones are encountered.

These vertical seams therefore, indicate the beginning of the Cozloo stage, which is best represented in the valleys of Zoongooldak, Kilimli and Tchatalaghzy. The strata in this zone dip

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respectively to the north and south so as to form an anticlinal fold which is plainly discernible in the valley of Kilimli. Twenty-five veins are distingueshed locally, but the absence of any detailed geological survey of the district and the lack of maps preclude adequate differentiation. The seams have an average thickness of 1.5 m.

A possible zone of transition marks again the upper level of the Cozlou stage. It is best seen in the vicinity of the Kiosseaghzy fault. Two systems of seams occur here and are known as the Tsamly and Beylik groups. The former comprises fairly thick seams some of which attain a maximum width of 2 m. Their dip is northerly, many being almost vertical. The Tsamly system can be traced to the very shore, at the village bearing that name. It extends over a distance exceeding 4 km. in length, to Camdilly valley.

The Caradon stage appears above this zone of transition. Eight seams are distinguished as belonging to this series. They have been worked at Caradon where they are well developed, as well as at Tchatalaghzy and Cozlou. Their thickness varies between 1 m. and 1.5 m. Beds of slate of an average width of 1.5 m. are intercalated between the seams. The Amasra basin, comprising the Tchatalaghzy district, also appear to form part of the same series. Five seams of similar average width are known here. It is also surmised that the outcrops east of the town of Amasra near Capoosou constitute the prolongation of this group. In addition a number of outcrops observable in the valley of Ilsou near Sefedler village probably bear the same relationship.

The coal mined at Heraclea belongs to the bituminous variety. It is slightly higher in ash than the corresponding average type from European basins. It may be divided into two classes: (1) that obtained from the veins of the middle series, containing from 30 to 40% volatile matter; (2) that mined from the lowest stage containing from 40 to 45% volatile matter. The first is excellent for coking purposes, while the Aladjaaghzy product is used chiefly in the manufacture of illuminating gas and for steam generation.

The following table shows the annual output for the entire region:

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ANNUAL PRODUCTION OF THE HERACLEA COAL-FIELD.

Years	Metric Tons	Years	Metric Tons
1884	70,997	1898	211,514
1885	80,129	1899	253,830
1886	88,892	1900	390,428
1887	97,846	1901	341,221
1888	109,409	1902	364,206
1889	146,366	1903	453,807
1890	137,282	1904	518,874
1891	166,230	1905	592,874
1892	168,727	1906	610,400
1893	173,456	1907	625,000
1894	159,687	1908	650,000
1895	147,445	1909	675,757
1896	166,170	1910	.....
1897	122,890	1911	750,000

ARMENIA.—A large number of coal seams of all grades are known to occur in the region extending east of the 34th meridian east of Greenwich to the Russian and Persian boundaries. Lignite was reported by Cuinet from Tavshandagh Mountain in the vicinity of Mersivan. The same observer noted coal outcrops in the immediate neighborhood of Tokat as well as in a district lying 60 m. southeast of that town. Outcrops have also been detected near the town of Sivas south of the previous named locality. In the northern portion of Mamouretulaziz, coal is known in a band, which practically extends from its eastern to its western boundary. The localities are Tchemishguedsek, where the coal is stated to be of good quality, Zanfranik, Dersim and Derstek. At Shengyah also, near Bailbourt, lignite occurs.

In the Erzerum province an attempt has been made to mine some lignite in the past few years. The seams are imbedded in the Upper Eocene. They are well developed at Kheneke, near Migri in the valley of the Arax, as well as east, in the Kashkaldagh Mountain. The annual production of the different localities is distributed as follows:

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PRODUCTION OF THE ERZERUM DISTRICT.

Locality	Production					
	1910			1911		
Kheneke (Narman)	1,300	Metric	tons.	450	Metric	tons.
Vartik (Trejan)	86	"	"			
Kukurtlu (Erzerum)	120	"	"	50	"	"
Sivishlu (Erzerum)	860	"	"	45	"	"
Tazegul (Erzerum)				20	"	"
Charel (Erzerum)				20	"	"

Proceeding southwards from Erzerum the occurence of deposit of bituminous coal is reported from the mountains lying west of the Mush plain. Southeast of the last named locality a hard variety of coal resembling anthracite is found near Erooh in the province of Bitlis. The coal is stated to occur in abundance in this region between the villages of Tchemak and Dergal.

The same variety of coal is found farther west near Palu. The meagre reports obtainable from this relatively inaccessible town lack definiteness and merely suggest the possible existence of an anthracite basin in this district.

West of the Persian boundary, the province of Van seems to have been favored by nature with ample reserves of fuel. At Kaskhalé in the Hekiari district a number of lignite seams 0.15 m. in width are known. Near Tcough Pass, at about two days horseback ride from Nordooz, the same coal occurs again. At Aktchai on the Karasou river and about 24 km. from the harbor of Cheraker on Lake Van, a number of seams occur. Their width occasionally attains 1 m.

CILICIA AND TAURIC REGIONS.—The existence of anthracite coal is reported from the vicinity of Beiroot-dagh Mountain, where iron has been mined since times immemorial by the natives of the town of Zeitoon. This region has been perhaps, least visited of all by travellers in Asia Minor. It seems strange that the neighborhood of the iron mines should not have stimulated exploitation of the coal.

Near Sis, between Adana and Zeitun, anthracite float has been detected in the valley of Jihun River.

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Two extensive Miocene lignite deposits, one in Kilissejik-Koi and the other in Yailajik-Koi, both in the vicinity of Aintab, were worked for a short time in 1911. The coal was seamed with thin layers of clays, and intercalated with iron carbonate. A local company of fifty merchants of Aintab City was organized to exploit this coal. But on account of no facilities of transportation, and on the declaration of Balkan war the operation was suspended.

Coal was mined about half a century ago in the northern section of the ancient province of Harpoot, about 45 km. east of Jesireh. The product was used for a while on river boats plying on the navigable sections of the Tigris.

In the lower Eocene foothills of the Taurus, north of Begil, between Akra and Zab, are good bituminous coal deposits in marls. They extend farther northward in the same line at Herbol and Segisik north of Jadi Mountain and in the district of Nurdus at Mervanen.

Similar beds are met within Taurus northwestward from Diarbekr, for example at Palu and at Chermak and Komur-Khan near the Euphrates.

Furthermore, coal is found east of Van, namely between Hazara and Rahmin, at Aghazuchai.

Coal is obtained at Sillir and at or on Kumach (Komur) and exists on the southside of the Merjan Mountain in the Dersim.

CAUCASIAN ARMENIA.—Brown coal and ligneous anthracite, suitable for technical purposes in beds of various ages are found in Caucasian Armenia. In the Migri Valley (west Karabagh) a brown coal is used as fuel. A Cretaceous brown coal exists at Bolshya-Keity, 10.5 km. from Alexandropol.

Brown coal of lower Eocene is found in the basin of the lower Araxes (west Karabagh and Karadagh) and is mined moreover in the basin of the upper Frat; for example, at Kirkut in Miriam Mountain. In the Chorokh basin coal mines exist at Karakana and Hortuk, south of Ispir and at Liesgaf, not far from Tortum, besides these there are some on the Lower Chorokh at Borchka. Brown coal often of anthracite-like origin exists in the Oligocene of the Imeritian and Trialitic region of too great amount of pyrite having not appreciable worth.

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FUTURE PROSPECTS.—From the foregoing review, can be summed up the following conclusions. In the first place, it is probable that the output from Heraclea will increase at a somewhat higher rate than hitherto, owing to the settlement of the political difficulties. The probable development of the eastern section of this coal district, namely the Amasra-Djide region, will also contribute to augment the yield of the basin. In this connection the need of topographical and geological mapping is keenly felt at Heraclea itself as well as in the neighboring seats of exploitation. Ralli's work on faulting will have to be supplemented by a detailed study of this important feature.

In the second place there exists a possibility of the development of numerous lignitic beds to supply the needs of local consumption. The annual production of this variety of coal has increased from 15,000 metric tons in 1898 to 32,000 metric tons in recent years. The industrial awakening of the country will eventually bring about a larger consumption of lignite.

Lastly, there exists the possibility of new districts being opened up. The development of an anthracite basin near Palu, and in the valleys of Sihun and Jihun Rivers, in Adana district, may eventually result from a thorough exploration of the region. The building of railroads through these sections of the country may constitute a factor of no mean consequence in the growth of the mining industry.

The quantity of coal consumed annually in Turkey, and such of the neighboring countries as are geographically dependent on it (Egypt for instance) can be safely reckoned at about 5,000,000 tons. The annual production of Turkish coal has been less than 1,000,000 tons.

PETROLEUM.

Although no complete explorations have yet been made, there is oil, or the indications of oil, in a number of places in Anatolia and Armenia.

Traces of oil are recorded at Cherkose-Deli, above Lake Isnik, southeast of the Sea of Marmora.

Boring for oil has been carried out near Ganos, Myriofito, and Hara, on the Sea of Marmora, with results which are reported to be of an encouraging character.

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Attempts to sink oil wells have been made at Mughla, south of Aidin City, and at Alexandretta.

In Kovak on the southeastern coast of Anatolia, north of Cape Chelidonia, a considerable oil occurs. This locality is the famous Chemaera of the Greek stories. Here gases are continuously disanged from fissures and are known to have been burning for 2800 years at least, for the phenomenon was described by Hesiod before the time of Homer. Tchihatcheff, the Russian Geologist, states that the gas is emitted from fissures in serpentine intrusive into limestone. It is interesting to note in this connection, that burning fountains of gas were long known in Baku oil fields, before the discovery of oil there. There is also on the coast of Albania (east shore of Adriatic) the locality of Polino, near Durezzo, where gas emanates from the summit of a hill, and often accidentally takes fire. The hill is said to be igneous, but the existence at the foot of it of an asphalt spring suggests an organic rather than a volcanic origin for the gas. Petroleum also has been reported from here and seems to have been exported on a small scale. This hill was the ancient Apollinia, and here the priestess of the famed Delphic Oracle sat and inhaled the fumes of gas till dazed, when her words were regarded as inspired.

It is there, an open question as to whether the escaping gas of the Chimaera (the modern Turkish name is *"Yanar tash"*—stone that burns) is of organic origin, and indicates oil below, or is volcanic, but the chances are perhaps, in favor of the former alternative, especially as the igneous rocks of the locality, (altered *peridotite*) is not one that indicates recent volcanic activity.

As is perhaps most often the case, there seems to be a general connection between petroleum and natural asphalt in these territories.

In a general belt running southeastward from the eastern part of Armenia, on the Black Sea, down to Persian Gulf, it seems likely that important oil fields can be developed. This is said to be the continuation of Caucasian fields.

Two important localities on this line, one in the vicinity of Erzerum, and the other near Van are already known to the American Standard Oil Company.

A spring of bitumen rises from the Eocene limestone within

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the cidatrel of Van, and oil is reported at Parghiri, whilst in the Muzur-Dagh range, on the Upper Euphrates, the Cretaceous limestones are locally charged with asphalt, and at Samasata or Soneisat, 70 miles southward, Plimy mentions the occurence of maltha or rock-tar. Petroleum is reported as found near Surmeneh, in Trebizond.

An extensive oil-field ranges from Hit on the Euphrates, for 200 miles upward to El Deir, and thence to the northeast, to Herboul near Zakhu, and eastward from this line to Beyond the Persian frontier. At many points in this vast area petroleum and gas exude with their usual concomitants, salt and sulphureous waters, often thermal, from the Miocene saline gypsiferous marls and limestones. The oil-wells of Hit, Jibbah, and Kerkuk are of great antiquity; those of Herboul, Hammam, Ali, Tel-Kiara, El Fahla, Tuz-Kharmatli, Kifri, and Mendeli are of less celebrity but possibly of greatly ultimate importance.

Oil bearing strata in Caucasian Armenia outcrop in many places along the Baku-Batum pipe line as in Gori, northwest of Tiflis, in Sharopan, south of Kutais, in Ozorget, on the Black Sea coast, north of Batum. Oil bearing strata outcrop also in many localities in the valleys of Kur and Araxes, as in Manasuck, Karakilissa, and Nakhitchevan district near Shah. These oil fields are not yet exploited and are reserved for future development.

The Caucasus is a recently (geologically) elevated range of mountains. It is at least newer than the petroliferous beds occuring in or contiguous to it, for productive oil-bearing strata are found at a great height on its flanks. At Grosny the oil is obtained from the summit of a range of hills, where the anticline is very acute, and the prolific strata only approach the surface, to a workable depth, within a very narrow width. An enormous area is covered by pertoliferous, which crop out at intervals over practically the whole base of the Caucasus, but of course only lie at a depth that allows of profitable boring, i. e., are prolific enough from a commercial point of view, over a comparatively small fraction of the whole. The enormous deposits extend beneath the sea (from the Apshiron Peninsula) where it is impossible to estimate their value or extent, and reappear in the Transcaspian provinces, which are yet only very

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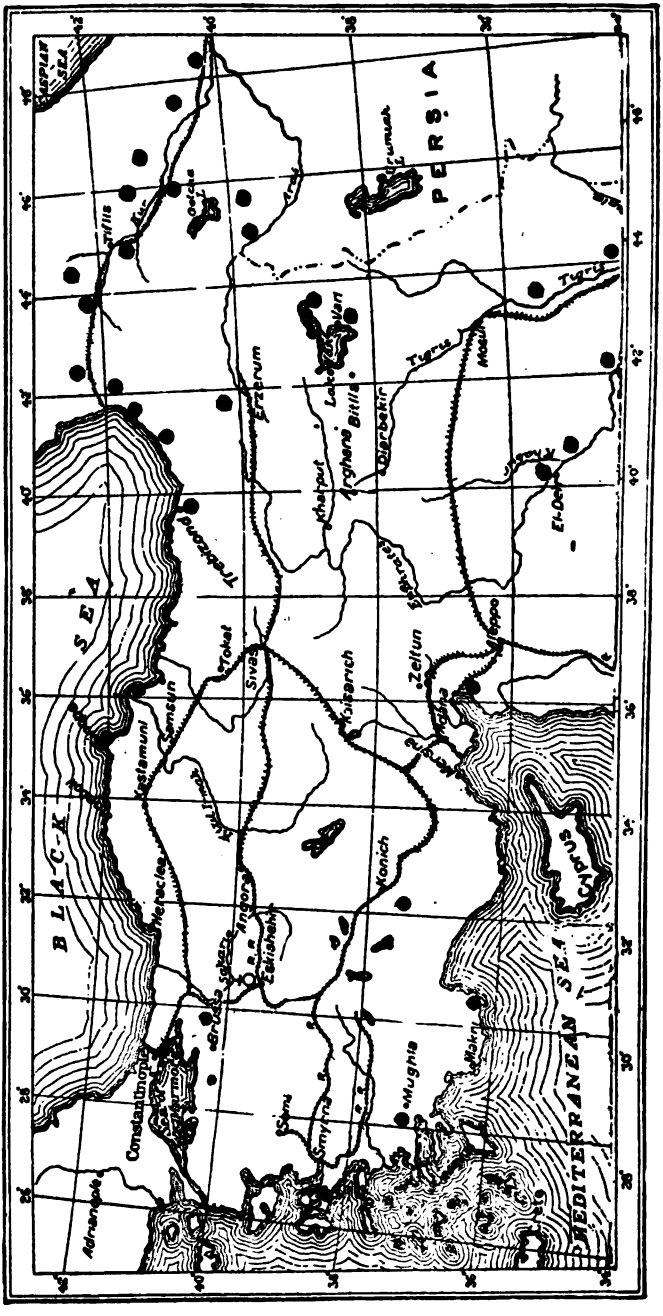

MAP REPRESENTING THE KNOWN OIL FIELDS OF ARMENIA AND ANATOLIA.

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imperfectly explored.

The Chatma Oil Field: The District known by the name of Chatma, lies about 50 miles from Tiflis. The nearest station is Poili, situated on the Transcaucasian Railway, about 300 miles from Baku and 260 miles from Batum, a station which is only connected with Chatma by a miserable track of some 18 to 20 miles long. The oil field is appoached by making a steep ascent from the railway and then following a series of plains shielded by high bare mountains; but the soft calcareous ground is so cut up with ravines, which traverse the plain in all directions, that great delay is occasioned by fruitless journeys unless the regular track is severely followed. The Chatma plateau is an almost level plain, about 8 miles long by 3 miles wide, flnaked nearly all around by precipitous cliffs which impart to the region a most imposing upheaval; for the strata have been forced into a vertical position, and on the flanks of the valley disintegration has been forced and caused the harder beds composing the hills to stand out, well-defined from the general formation.

Indications of oil are common along the cliffs, and not only are beds of hard compact, black bitumen, which the local peasants call coal, discernable, but there are deposits of highly discolored oil sands, from which a little heavy oil exudes, and thick deposits of Kir at the base of the cliffs, which can only have originated from effusions of oil. In some places tiny evolutions of oil and water may be traced oozing from cliffs, which flow into shallow trenches excavated by the natives for its reception from whence the floating oil is periodically skimmed for employment in household operations. At the base of the cliffs at the west of the valley the outcrop of an oil sand may be traced for a long distance along the ground, and into this a number of wells have been bored, by primitive hand-boring appliances to a depth of 50—150 feet, which have yielded small quantities of black petroleum of a specific gravity exceeding 0.920. The strata cannot be so readily traced in the centre of the plain on account of the disturbed conditions of the surface material, although where traces are visible the same acute angle is observable, but as there are a number of mud volcanoes which constantly eject mud and water contaminated with oil, one way

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fairly assume that the oil-bearing beds continue across the plateau. The verticality of the strata, exposing a broken edge to the surface of the ground, naturally permits all the oil bearing beds to expel their contents, so that little can be expeced from such oil strata unless penetrated to a great depth.

The most likely spot to secure a fair production would be near the apex of the anticline, or, in the event of there being two or more species of these, so that unbroken and unexposed strata may be tapped.

The oil field composing the four districts of Balakhany, Saboontchy, Romany and Zabrat is situated on an almost level plateau about 175 feet above the Caspian, or about 260 feet above the ocean-level. The total area of the plateau under exploration, comprising the four districts, is no more than 4 square miles, 2560 acres. The oil field connected with Baku, which lies about 8 miles to southwest, by railway having its destination in the village of Saboonchy, but thereis also a first-class macadamized road leading from Baku, which is largely used for the transport of oil-well requisites as the railway.

The plateau is sheltered on the northeast, east, south and southeast by limestone rocks, which overlie the oil beds where they dip down acutely. On the west and northwest, the oil beds outcrop at the surface, and continue for may miles exposed on the surface of the ground. From Romany towards the west there is a steady rise of the strata, the dip being about 1 in 16; but at Romany the dip is great and the angle of dip shown by the overlying limestone is approximately correct, the angle is about 30°. A section of the ground in a direct line between the Romany and Bogboga, near the village of Balakhany will be very nearly at right angles to the strike of the beds, and therefore, will disclose the true dip of the formations.

There are 8 well-defined oil zones, separated from each other by variable thickness of strata, that range between 70 feet and 150 feet; but below this the water sand is struck, which makes it difficult to ascertain what oil lies beneath. The series of sands which underlie the well known oil formations have been penetrated to a depth of 400 feet, sometimes with good results and sometimes without any reward, and although many of the varieties of sand passed through are of the fine "blown" type

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and deeply discolored by pertoleum, there appears to be much difficulty in overcoming the water and thoroughly testing the sources at such a great depth.

Bibi-Eibat Oil Fields: This field is situated about 3 miles due south from Baku, from whence all materials are carried by road, as there is no railway connection. The valley which is fringed by the sea on one hand, and by a semi-circle of almost precipituous cliffs behind and around, has an area of about 1.6 square miles, i. e., 1024 acres of which only about 40 percent. are under exploitation.

The formation of the Bibi-Eibat field partakes of the character of a regular cone. On all sides except, perhaps, the sea quarter, the strata descend, and where the limestones are reached which cover the oil series, steep cliffs are produced that might easily be mistaken for faults by a casual glance. The huge limestone masses which surround the valley produce an imposing spectacle. The oil strata do not slope acutely on sea quarter, for there are evolutions of petroleum gas in the sea itself, and it is reported that at one time such escapes were more prevalent.

The Binagadi Oil Field: For several years exploitation has been conducted in a district to the west of Balakhany near the village of Binagadi. The region has long been knokn to the oil-bearing, but no active exploration was commenced until an oil prospector sank well, and struck an oil source in 1896. Since that date other wells have been bored around the original site, and further interest has been attracted to the place by the appearance of a small fountain, in 1901, which yielded about 100,000 poods of petroleum. The oil is very heavy, exceeding, generally 0.900 sp-gr., and the wells rapidly dry up when bailed.

The strata of district are similar to those of Balakhany, consisting of calcareous clays, sandstones and petroliferous sands, but the strata outcrop at the surface at an acute angle, and permits the escape of gas from the strata might otherwise be employed in expelling the oil. The prospect of attaining oil in payable quantities, at a reasonable depth, are remote, although deep boring might disclose the existence of prolific sands where they are uninfluenced by the surface exporsures.

The situation of the Binagadi district is not unfavorable lying as it does only about 7 miles from the Backtown refineries

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and the sea-shore, whilst the railway junction of Baladjari is not more than two miles from the oil properties.

The Puta Oil District: A well-defined anticline sweeps all around Baku, the apex of which concedes with the base of a valley that follows the coastline for many miles after approaching the western side of the Bibi-Eibat field. The Puta railway station lies about 8 miles owing to the fact that he Trans-Caucasian Railway keeps to the valleys in order to escape the limestone range that divides Baku from the hinterland. The plain is perfectly devoid of vegetation, as a result of the escape of sulphurous and other gases as well as salt water. In Winter, many miles are rendered quite impassable by accumulations of water, and in the Summer the heat and glare rival many parts of the Sahara. The district has attracted more than superficial attention through its proximity to Baku, and as a result of the many indications of oil that are everywhere apparent in some form or other.

The beds forming the anticline have been forced into an almost vertical position, consequently exposing the fractured-edges of the strata on the surface of the plain, and in consequence formations of divers characters may be recognized for long distances. Hills of asphalt have been formed in some places above the vertical petroleum beds, whilst in other cases exudations of gas only occur.

As far back as 1897, the Messrs. Nobel sank a boring near the outcrop of one of the beds, and at a depth of a few hundred feet a little flow of heavy oil was struck and the well until this day discharges continuously a small quantity of thick black oil, resembling tar in consistency and appearance. This land is held in reserve.

KHORDALAN:—Khordalan is a small Tartar village lying about 4 miles southwest of Binagadi and 7 miles northwest of Baku. Indications of oil are prevalent everywhere in the vicinity and the railway which passes close to the village, has been excavated in the side of a hill where an excellent section of strata is exposed to full view. The cutting actually passes through strata wherein oil beds are interposed, from which a gentle stream of heavy oil constantly flows and collects in trenches provided for its reception at the base of the bank. The nature

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of the soil is evidently more conducive to the growth of vegetation, for a coarse grass coats the earth and a little agriculture is permissable. The Russian Petroleum and Liquid Fuel Company who have been boring a well on a plot to the south of a hill near the village of Khordalan, in the Spring of 1903, ,met with a strong fountain which threw up a large quantity of sand and oil at a moment when the tools were at work in the well, thus causing their loss and leading to delay in the exploration. The results to some degree satisfactory, do not yet justify the drawing of any conclusion and fuller investigations must be conducted to discover the practical worth of the field.

DIGGA, SARAI, etc.—A large area to the northeast, west of Binagadi is known to be oil bearing from the frequency of such phenomena as exudations of gas, oil and salt water, escapes of sulphurous gases, and prevalence of mud volcanoes. Digga, Sarai, and other villages have transmitted their names to districts which surround them, where large areas are laid out and held under lease by many of the Baku Companies and by private individuals.

In the intensely interesting region of the Caspian Sea, so many phenomena of interest may be seen in operation around its shores, that a description may be of value in assisting the reader to realize some of the conditions that may have had a more or less direct relation to the region of petroleum. The Caspian is an inland sea, covering an area of from 170,000 to 180,000 square miles, from which there is no outlet, the level of the water being about 84 feet below the level of the Black Sea. The Caspian is in reality the diminuative representative of the immense expanse of ocean which at some time during the Tertiary perod was connected with the Black Sea and Mediterranean, and extended over a large area of Europe north-westward of the Black Sea, and a still larger area of Asia to the east and southeast of the Caspian. The Caspian was doubtless cut off from the oceans to the west at the times that the Caucasian range was thrust up, and from the oceans to the southeast during those orographic changes which resulted in the Himalaya Mountains and the highlands of Afganistan and Persia, so that any information that can be made to fix the period when the Caspian was isolated from the oceans.

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That connection with the open sea did once exist is proved by the character of the dissolved salts in the water of the Caspian, and by the fish which abound in the sea. Myriads of fish accumulate around the mouths of the rivers running into the Caspian, and thousands of tons are annually caught and forwarded to Russian market, but many are, probably on account of the brackishness of the water, profoundly modified varieties of ocean fishes, if not actually distinct species and indigenous to the Caspian. They are particularly of greasy nature. The well known Caviar, for which the Caspian is famuos, is simply the roe of the sturgeon, and this oily nature characterizes many of the fish. Whether it has any bearing on the origin of oil one is not yet prepared to say, but it is a fact worthy of note.

The amount of water which flows into the Caspian Sea cannot be less than 30,000,000 cubic feet per minute, on an average, for measurements have shown that the Volga alone, which drains nearly half a million square miles of land, discharges sometimes as much as one and a half million cubic feet of water per second, and besides this there are the Ural, Terek, Kura, and Arax, and many others. If this estimation of the water flowing into the Caspian is correct, the annual evaporation must equal this amount, that is to say, 3 feet of water annually, or an average of nearly one tenth of an inch per day must be evaporated to keep the Caspian Sea at its present level. The amount of salt in the deep southern part of the Caspian—for the northern part of the Caspian is not more than 50 feet deep, is 2 percent. ,only, whereas the oceans exhibit 3.5 percent. of salt. This peculiarity revives a special interest which the evaporation is equal to the supply of water, cannot only have failed to increase in density, but actually decreased in salinity from 3.5 to 2 percent., since it has cut off from the sea.

On the eastern shore of Caspian is a large basin, named Karaboghaz, separated from the open sea only by a mere strip of land, and whose only communication with the open sea is by a narrow channel about 150 yards wide and 5 feet deep, through which a continuous but fluctuating stream of water, averaging 3 miles per hour, flows, the current being entirely due to the intense evaporation set up in a confined shallow area. The total area

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of Karaboghaz is about 8,000 square miles, and Von Baer, who has specially studied the Caspian estimates that no less than 350,000 tons of salt are daily abstracted from the sea by this basin alone. As there are many other similar basins of smaller dimensions on the eastern and southern shores of theCaspian, and on the northern shores enormous lagoons where salt is deposited in a manner very much alike at Karaboghaz, a reason is found for the brackishness of the Caspian, and an explanation is forthcoming for the intense salinity of some of the strata fringing the coasts.

Into this huge basin are swept daily thousands of fish, which cannot survive the intense salinity of the water, and whose remains must be deposited together with other sedimentary matter. (The Russian Government has under its consideration a scheme for closing the channel to this basin in order to save the fish.) Violent sandstorms periodically sweep the region of Karaboghaz, and one is led to inquire whether the deposition of huge quantities of known oily fish remain in a deposit of salt, and probably sulphate of lime, where practically the only silicous matter is sand conveyed by winds, is not forming the material for a future oil field, not unlike, in some respects, the existing oil fields.

SALT.

Salt occurs in Anatolia and Armenia abundantly in two different modes; first, in beds and masses of rock salt, intercalated between the strata of different geological periods; second, as products of evaporation of recent periods, due to arid climate.

The salt mining in these countries was closely controlled by Turkish Government and the revenue was assigned to the Public Dept. administration. For this reason the exact statistics of production have never been obtained. But, yet, approximate production is said to arrive to about 6,000,000 dollars per year. One fourth of the entire production has only been exported to India.

Salt was manufactured all under the charge of officers appointed by the state, in three ways:

1. By evaporating sea water.
2. By evaporating the brine from salt springs or lakes.
3. By mining rock salt.

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ROCK SALT.

The beds of Tertiary rock salts are generally attached, by Tchihatcheff, to Miocene. It is probable that this long track of Helvetian is the continuation of the chain of Tertiary beds, extending from Europe to Anatolia and Armenia, and thence to Persia and to the Aralo-Caspian regions.

On the east of Kizil-Irmak the quarries of salt are exploited long ago at Dekilo, Tepesidelik, etc.

The salt at Tchayan on the north of Loungourlu is also exploited.

On the west of Kizil-Irmak and on the north of Angora, the deposits of Gangra (Tchangry) still retains its reputation from medieaeval ages up to present time; and the mines of Maghara and Balybagh are still in a very promising condition.

On the south of Kizil-Irmak, 50 Km. northeast from Kaiserieh. the mines of Pallas and the Touz-Koi are important. At Touz-Koi there are cliffs of salt with banks attaining 12-15 meters

On the west of Perghama, a deposit of rock salt which for a long time called *white rock* (Leuké) strikes the eyes of the men who enter the boat in the Gulf of Smyrna.

These beds are continued further to the east, between Erzerum and Erzingan. Tchihatcheff mentions calcareous salt deposits traversed by dolerites in the valley of Moushlou-Su. These are equally connected to Miocene.

At Olti in Armenia, the salt is obtained from a depth of 16 meters.

A rock salt of Miocene age is mined at Nakhichevan, Kulpi, and Kagizman in the Araxes Valley. At Kulpi a hill of rock salt covers an area 1.5 verst and that salt has a thickness of 150 meters. The single banks are 2.2 meters thick.

A rock salt is found and worked near Van and at several other points in the eastern mountains. Very little is known about these workings. Here, an immense track of rock salt of Miocene age is extending from Lake Van to Lake Urmi.

At Hazo, on the southern border of Taurus, is found a very pure rock salt, in sheets of one inch thick.

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SALT PRODUCED BY EVAPORATION.

(*Marine or Lacustrine.*)

The Lycaonian plateau is the most important saline region in Anatolia. The centre of Asia Minor, the greatest depression between Pontic and Tauric chains, has been a lacustrine or marine basin since Miocene; but, moreover, the salt has been concentrating in pools by evaporation, since Pontian epoch.

Among these saline basins the Touze-Tchollu or Geullu is known from antitquity which Strabo cites for curiosity. Sodium chloride is the chief constituent which attains to 32.2 per cent.; strongest of all saline basins so far known. While this lake is heavily charged with sodium chloride on one hand, the Lake Murad-Geul is in its vicinity, charged with magnesium chloride on the other hand. The Boulouk-Geul, near Eskil, contain sulphate of magnesium and sodium.

In extensive central depression of Anatolia the rainfall is collected in saline lakes. In former times when the climate was more moist than at present, these now landlocked basins, probably, discharged their overflow seawards. But the old freshwater lakes have been transformed to salt lagoons by the gradual dessication of the land and the excess of evaporation over the rainfall in the basin of Kizil-Irmak gives it a brackish taste. In the Sivas plain it traverses beds of pure salt, where the natives of Western Armenia derive their usual supply.

In the lacustrine region of Central Anatolia seems to have formerly formed part of the Sakaria basin, at least for the greater part of its extent. Here the largest sheet of water is the Tuz-gol or "salt lake," which is at least 60 miles long northwest and southeast, nowhere less than 3 or 4 miles wide. It covers a total area of over 400 square miles, but in summer its mean depth is probably less than 7 feet. Towards the centre are seen the traces of a dyke over 7 miles long constructed by a Sultan for military purposes, and here the water is nowhere much more than 3 feet deep. During the dry season its outlines could scarcely be recognized but for the plants growing along the shore, beyond which an unbroken deposits of salt stretches for many miles in some direction. In winter the whole depression is flooded but even then the surface is covered by a saline crust from 2 inches

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to 6 7 feet in thickness, and generally solid enough to support a man on horseback. According to Phillips, the water of the Tuz-gol is heavier and more saline than that of the Dead Sea, containing over 32.3% salt, with a specific weight of 1.40.

West of Tuz-gol the plain is studded with numerous ponds, tarns, salt pools, swamps, and rivulets, which evaporate in summer, and which besides salt, often contain sulphate of magnesia and soda. The temporary lakes stretching to the south and west are also charged with bitter magnesium salts, without any admixture of chloride of sodium. Such phenomena are common enough in closed basins, and are due to the different chemical constituents of the soil traversed by the streams.

Besides the steppe lakes, evidently the remains of an older and more extensive basin which drained northwards through Sakaria, there are other reservoirs, where although now occupying distinct cavities in almost closed cirques, appear to have belonged to the system of seaward drainage. Traces of old communications are indicated at several places by channels and ravines still showing the marks of running water. To the same marine basin of Central Anatolia apparently also belonged the reservoirs scattered over the depression lying between the Emir-dagh and Sultan-dagh, and which are alternately flooded basins and simple meres surrounded by aline incrustation.

In Armenia the Lake Van, on the south of Ararat, and lakes Urmi, Khosapin and others, on the east of Ararat, are also more or less arrived to the saline condition. Most of these lakes are formed in Pliocene, following the recent principal movements. Some of them are due to detritus deposits, and represent stratigraphically the stage of Pliocene, by lacusrine sediments. Others have had free drainag and are remained from lakes of sweet waters, like Gokcha, Chaldir, Toporavan and Nazik; some of them manifesting still a degree of saline evaporation like the lakes Khozapin, Urmi and others on the east of Ararat. Between these lakes are seen ancient terraces ascending to the level of primitive waters and show evidences of falling down by the effect of the gradual evaporation.

In the Lake Van, the proportion of solids in solution, principally carbonate of potassium and sodium chlorides and sulphates, is very large while the amount of suspended matter is very trifling.

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It is estimated that he alkalinity is equal to rather more than 3.25 ounces of ordinary soda crystals dissolved in a gallon of water.

This lake comprises an area of 1300 square miles, at an elevation of 5737 feet. Its extreme length would seem to measure 78 miles, and the breadth from north to south of the principal body is about 32 miles. To all appearances it is very deep except at the northeast and southwest extremities. The color of the sheet of water cannot be given in a single word; it varies with extraordinary range of scale. A cobalt blue of great brilliancy is perhaps the most frequent hue. A certain milky paleness becomes invested at morning and evening with an infinite number of delicate tints. Only one kind of fish is found in Lake Van, resembling a large bleak.

Samples are taken from the waters of Lake Van by different analysts and results are given in the following table:

QUANTITIES OF SOLIDS IN SOLUTION ESTIMATED IN PARTS PER 100,000..

	Chancourtois	Abich	Serda	Thorp.
Chlorine	556.68	488.12	579.12	568.90
Carbonates	329.06	249.45	328.64	320.57
Sulphates	312.78	188.48	198.47	203.40
Phospate	.....	.....	0.15	0.05
Nitrate	.....	.....	.....	.....
Soda	1206.37	862.82	1040.87	1115.92
Potash	29.75	29.23	52.81	39.92
Magnesia	26.21	21.29	27.31	Not. Det.
Lime	.....	.....	5.24	.....
Strontium	.....	.....	0.63	.....
Iron Oxide	.....	.....	0.30	.....
Maganese Oxide	.....	.....	0.22	.....
Ammonia	.....	.....	0.57	.....
Silica Alumina	18.00	trace	7.29	7.53
Alumina	.....	3.58	0.35	1.01
Total solids	2260.00	1734.21	2110.98	2248.9
Suspended Matter	.....	.....	a little organic matter	0.39

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CALCULATED COMPOSITION IN PARTS 100,000.

	Chancourtois	Abich	Serda	Thorp.
Sodium Chloride	938.00	810.67	953.84	938.84
Sodium Carbonate	861.00	543.84	714.43	773.11
Sodium Sulphate	333.00	258.68	266.53	369.09
Potassium Sulphate	55.00	54.06	97.66	73.82
Magnes. Carbonate	55.00	40.71	57.31	Not. Det.
Magnes. Sulphate	.....	22.67	.....	.....
Calcium Carbonate	.....	.....	4.70	.....
Calcium Sulphate	.....	.....	5.93	.....
Calcium Phosphate	.....	.....	0.32	.....
Strontium Sulphate	.....	.....	0.11	.....
Iron Carbonate	.....	.....	0.49	.....
Magnes. Carbonte	.....	.....	0.36	.....
Ammonium Chlor.	.....	.....	1.69	.....
Silica	18.00	3.58	7.29	8.53
Alumina	.....	.....	0.34	101
Nitrates	.....	.....	.....	.....
Per Cent. of Solids	22.6	17.34	21.10	22.48

The specific gravity of the water was determined by Chancourtois as 1.0188, and by Abich as 1.0189, both at 19°C. As Abich points out the water of Lake Van is nearly identical in composition with that of some of the Soda Lakes at the southeastern foot of Ararat, in the Araxes plain. In some of these the Chloride, in others the carbonate, and in others again the sulphates of Sodium is the predominating constituent. Probably the composition of the waters of Lake Van vary somewhat in different parts of the lake. Abich's sample certainly is less saline than those of the other analysts.

Abnormal salinity is a special feature about the waters of Lake Urmi, and extensive beds of rock salts are found in their vicinity. It has been estimated that they are six times as salty as the ocean; though only three-fifths as heavily charged with saline matter as the waters of the Dead Sea.

Lake Urmi is situated at an elevation of 4100 feet, covering an area of 1823 square miles. Its extreme length from north to south is 80 miles, and its breadth from east to west 24 miles.

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It resembles its neighbor on the west in constituting an isolated basin, many rivers flowing in but none out. On the other hand its significant depth invests it with the character of a lagoon. The average being not more than 20 feet and maximum 45 to 50 feet. Evaporation must be very rapid over such a sheet of water. The color is deep azure, neither fish nor molluscs can live within them. Shores are impregnated with salt; upon the margin are found fragments of fossil coral and shell.

The following analysis of the extraordinary saline waters of Lake Urmi are appended for contrast rather than for comparison with those of Lake Van.

LAKE URMI.

QUANTITIES OF SOLIDS IN SOLUTION ESTIMATED IN PARTS PER 100,000.

	Abich	Gunther & Manley
Chlorine	12,686.80	8,536.00
Sulphates	929.03	631.20
Soda	10,106.40	6,814.00
Potash	.....	140.00
Magnesia	1,099.30	626.60
Lime	37.70	70.60

In this case Abich's sample was a stronge solution than Gunther's, the percentage of solid salts being 22.28 and 14.89 respectively. Yet the relative proportion of the various salts is very similar as shown by the following comparison of percentages:

	Abich	Gunther & Manley
Sodium Chloride	86.37	86.20
Magnesium Chloride	6.94	6.82
Magnesium Sulphate	6.08	4.15
Calcium Chloride	0.27	....
Calcium Sulphate	0.34	1.15
Potassium Sulphate	....	1.74
	100.00	100.061

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The specific gravity in the two cases were determined as 1.175 and 1.113 respectively.

BORATE.

The borate of Anatolia is a particularly interesting deposit, which in the past, played an important factor in the world's commerce. Extensive beds of borate, a massive and not entirely pure variety of Colemanite, a calcium borate, are mined at Sultan-Tchair, in the province of Hudavendighiar. The mines lie on the mail-route leading from Panderma harbor to Balikesser 11 Km. south of Susurlu. For this reason the exploited borate, the borate of hydrated calcium, is shipped to the port of Panderma and called by the name of Pandermite.

According to Weiss the pandermites occur in Tertiary sedimentaries lying in a basin surrounded by steep hills of gabbro, granite and crystalline schist. The productive beds consist of a brownish to bluish gray gypsum, containing nodules of variable sizes dispersed within the gypsum and forming from 10 to 20 per cent. of the aggregate mass. This mine produces 10-15000 tons of borate annually valuing approximately 2,000,000 fr. An English company organized in 1880, produced 7400 tons annually. A French company organized in 1891, produced 5,000 tons of borate from the mines of Azizié. Finally these two companies united by the name of "Consolidated Borax Co."

The deposit of borate in Sultan-Tchair comprises an area of 8 square km. In this basin are accumulated the sedimentary deposits whose superior part only belong to Tertiary and contains the beds of borate. The top is covered first with about 80 m. thick grits and schists, and then with a mass of argillaceous gypsum attaining 30 to 40 m. thickness, and lastly with banks of calcareous rocks and conglomerates. The pandermite is very ultimately associated with the gypsum on the banks in an irregular thickness. It is also found that some compact anhydrates have exteriorly the aspect of marble and white silicate of magnesium and lime. The density of mineral attains to about 2.5 and it is distinguished by this capacity and by chemical composition from the light borate of Chili.

The beds contaning pandermite have a declination of 5 to 15

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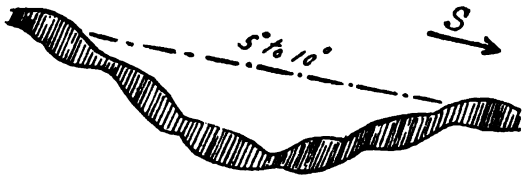
degress to the south in a lanticular shape. The thickness of beds falling down rapidly from 5 to 0. m.

The origin of the pandermite must evidently be same as the borate deposits of Staasfurt, Chili and California. The evaporation has given chance to boric acid to combine with diverse bases produced from surrounding rocks. It is said that the straasfurtite, the double salt of sodium borate and magnesium chloride, is found in a salt bearing hill. In California either ulixite, sodium and calcium borate, or priceite, borate of lime,



THE LENTICULAR BEDS OF PANDERMITE IN SULTAN-CHAIR.

are formed with the chloride, sulphate and carbonate of sodium, for these two cases lagoon character of evaporation is not contestable. But the prior presence of abnormal quantity of boron must also be considered. This may not be attributed to the constant supply of weak boric acid in the sea water; because any other large region has not given any borate under similar conditions of concentration. It must be kept in mind that boric acid is also supplied by hot springs and salfataras of volcanic origin, or from emanations of fumerols or jets of steam issuing from the ground.

Another region rich in borate, under similar conditions, is the Lake Urmi. After Abich a mineral water containing ½ per cent. borate of soda is observed in contact with eupholite and serpentine, same condition as the saline beds, associated with ophites, of Pyreneese.

The International Borate Company was tending to control these deposits. Since the levy of royalty of 16 per cent. on the gross products, work has not been carried on as extensively as heretofore. The annual output ranges:

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Years	Metric Tons
1894 1895	3,033
1896	2,602
1897	2,412

PANDERMITE.

1892	11,622
1893	9,100
1894	9,080
1895 1896	12,626
1897	11,375
1900 and after	10 to 15,000

The following table shows the position of Anatolia in the production of borate, in comparison with other great producing countries:

	1897	1899	1901	1903
United States	17,600	21,834	16,227	31,000
Chili	3,168	14,951	11,450	16,870
India	280	250	162	.....
Germany	198	183	184	159
Italy	2,704	2,674	2,558	.....
Peru	11,850	7,638	.....	.....
Turkey	11,375	10 to 15,000 tons per year.		

	1904	1905	1906	1907
United States	41,400	42,000	52,770	48,440
Chili	16,730	19,610	28,019	28,370
India	.....	.....	.....	.....
Germany	135	183	161	114
Italy	2,624	2,700	2,561	2,305
Peru	.....	.....	.....	.....
Turkey		10 to 15,000 tons per year.		

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EMERY.

The emery has also been a substance of great industrial importance playing a great rôle in the world's commerce.

By the settlement of the political situation it is hoped that the new resources will soon be exploited and the production will be doubled or trippled.

The mineral which was first obtained from the Grecian Archipelago, was discovered in Asia Minor by L. Smith in his explorations, which lasted from 1844-1847. At first the emery was found in scattered masses on ridges formed mainly from a bluish limestone. There were the least remains of the stone in which the mineral was originally embedded.

The emery is found in a district extending from the Gumughdagh, near Lokia, to Kutaya, also west of Koola and north of Smyrna, in fact, on nearly all the ridges separating the river valleys in this region.

Further to the south along the small rivers running from the mountain range boulders of emery are found mixed with gravel which have probably been carried down from the mountains. The region is composed of talcose and chloritic slates passing into mica slates, with large beds of limestone.

The mines lie in a belt extending 200 miles south and southeast of Smyrna. Noteworthy localities are Cozbounar, Kuluk Azizié, Bahchejik, Hassan-Chaushlar and Saka, on the Aidin railway, 50 miles south of Smyrna.

The richest and best situated deposits of emery are in the Gumugh-dagh, and along the railroad which has been built from Smyrna to Aindin. Here the emery is found in pockets, some of which are several meters across, embedded in limestones. The rock is very hard and tenacious, and is difficult to break. As mined it is a mixture of corundum with magnetite and hematite. Occasionally it is accompanied with chloride with inclosed octahedral crystals of magnetite. Its sp. gr. varies from 3.75 to 4.30, the principal constituent being 60 to 70 per cent. aluminum oxide, 9 to 33 per cent. iron oxide. The remaining constituents are oxide of calcium, silicon dioxide, carbon dioxide and water.

The original grant for working emery mines was purchased by Mr. Abbot for an annual payment of $55,000. He already

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held a contract for mining emery from the Greek Government, and later entered into a partnership with the English firm of John Taylor and Son.

The chief mines in Turkey are opened by shafts and galleries, explosives being used in the extraction of the mineral. At the Jackson mine a steam-pump is employed, the one lying at considerable depth and water being encountered. At one of the Abbot mines the emery is dug up from the red argillaceous earth of the surface. The larger pieces are broken at mine by heating and then cooling suddenly with water, being finally reduced by sledging.

As to the origin, Dr. Lawrence Smith came to a firm conclusion that emery has been formed and consolidated in the limestone in which it is found and that it has not been detached from the older rocks as granite gneiss, etc., and lodged in the limestone at its period of formation.

All the emery mined is shipped from Smyrna, the United States taking about 60 per cent. of total and Great Britain about 40 per cent.

The cost of production at the mine is estimated at 8 dollars per ton.

Emery deposits are also found in Khatchbulach, Caucasian Armenia, 45 Km. south of Elizabethpol.

ANNUAL PRODUCTION.

Years	Metric Ton
1893	8325
1894	6034
1895	6591
1896	3000
1898	62353
1899	24475

MEERSCHAUM. (Sepiolite)

To the sepiolite of Asia Minor is often given the preference on account of its ready adaptation for certain uses in jewelry. It occurs in masses in stratified earthy or alluvial deposits, where it has been formed from the decomposition of megnesium car-

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bonate which is imbedded in serpentine, in the surrounding mountains. It is richer in silica than that found in Utah and in North Carolina.

The plains near Eski-shehir, in Asia Minor, constitutes one of the important localities from which this hydrous silicate of magnesium is mined. The meerschaum district extends from the town of Eski-shehir, on the Anatolian railway, almost due eastward to the City of Angora. The mines lie at a distance of about 22 Km. from the railroad station, to which the ore is packed by camel trains. The chief producing mines are those of Saresu, Sepki, Sepetji-ojaghi and Kemikji-ojaghi, at a distance of three miles from the other.

The deposits occur in a valley filled with drift material from the surrounding mountains. The sepiolite is scattered through the drift in rounded nodular masses with fragments of magnesium and hornblende rocks. As a rule the nodules do not exceed 3 inches in diameter, but a few attain larger dimensions. In row condition the mineral is soft, light, and non-transparent. The color is white, with occasional blending of yellow, red or gray. The thickness of meerschaum bearing strata varies between 10 and 130 ft.

Almost all the meerschaum mined in Asia Minor was controlled by Austrian dealers and finds its way to Vienna, where it was used extensively in the manufacture of pipe heads and cigar holders.

Mining is carried on by means of leasing system, both in open cut and underground work. Pits from 25 to 120 ft. deep are dug, and as soon as the vein is struck, horizontal galleries, sometimes of considerable length, are made, but more than two galleries are seldom to be found in one pit. The stone as extracted is called *"ham-tash"* rough block, and is soft enough to be easily cut with a knife. In this state the blocks are purchased by dealers on the spot, not by weight, nor by measurement, but according to proximate quantity, either per load of three sacks, or per cartload. The price varying from 25 to 150 dollars per load, accordingly to quality. These rough blocks are dried and subjected to certain preparations before being conveyed to Eski-Shehir. The manipulation required before they are ready for exportation is long and costly. The clayey soil

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attached is removed, and the meerschaum is dried. In summer exposure for five or six days to the sun's rays suffices, but in winter a room heated to the required temperature and the drying takes 8 to 10 days. When well dried the blocks are well cleaned and polished; then they are sorted into about 12 classes, each class being packed with great care in separate cases and each block being wrapped in cotton wool. The dimensions of these cases vary according to the five classes they are divided into, in accordance with the Zolwein system, which has been recently generally adopted owing to the fact that the bulk of the meerschaum is sent to Vienna, where it is worked and dispersed all over the world, the most of the finest specimens are sent direct to Paris. Certain American dealers have visited Aski-Sehir with the object of obtaining the raw articles direct instead of through Vienna, thereby saving the higher custom house duty payable on the worked meerschaum. The quantity annually exported is put down at 8,000 to 10,000 cases.

It is maintained locally that the Eski-Shehir meerschaum is superior to that of Sebastopol and Caffa, in the Crimea, of Egrilos (Negropont), and of Corinth.

SULPHUR.

Sulphur occurs in Anatolia and Armenia commonly in the hot springs, both active or extinct, in Tufas or volcanic tuffs, and great deal in the sedimentary beds in close association with gypsum.

Brimestone deposits exist in Dardanelles peninsula, in beds of clay and is mixed with bitumen. In volcanic islands sulphur is found in several places.

In the Armenian mountains beds of sulphur also exist. Sulphur is dug at Bechanach in the Daralagoz district. These contain quartzose clay layers, about one meter thick of Miocene age, containing 24% sulphur. At Gumur in the same district trachyte is overlying the sulphur. Moreover there exist sulphur mines at Daata, 7 km. from Diadin. There a layer of pure sulphur 8 cm. thick lies under a breccia cemented with sulphur. That rock which was deposited from sulphur springs of Diadin contains 18% sulphur. 65.72% anhydrite.

The deposits from the fumerols of the Tendurak volcanoes which are in solfatine condition, yields 73% sulphur.

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ALUM

Many alum deposits are known to occur in Asia Minor since memorial times. None but one is exploited, in the vicinity of Shabin-Karahissar.

The small city of some 13,000 inhabitants in the eastern parts of the province of Sivas that bears the official name of Karahissar-Sharki, or Eastern Kara-Hissar, is generally known on maps and in common conversation as *"Shabin Karahissar"* (Shab meaning alum). It seems certain that the alum workings within a short distance from the town have been in operation for at least 300 years, and have given the designation of *"Shabin"* to the town just as Afion "Opium" Kara-Hissar in western Anatolia, and a small town called Develi (place of camels), Kara Hissar near Ceasarea, have acquired their names through some features in the regions in which they are situated. The term "Kara-Hissar" is applied to a peculiar outcropping of blackish rock in the form of a tall peak or mountain that exists near each of these towns. The hills against the sloping of whch Shabin Kara-Hissar is built is surrounded by a well preserved masonry town and fortress that must have been very strong in the days of mediaeval warfare.

The alunite of Shabin Karahissar is found in the regions comprised between the city of Shabin Karahissar and the village of Lidjesi. The mine is very remarkable not only by its geology but by its industrial importance. The alumite is found in the Tertiary syenite rocks. The mineral contains both alum and alunite which is analized by Mr. Rivot, the director of the laboratory of the School of Mines of Paris.

Silica	35.75
Aluminum	14.80
Iron Oxide	1.20
Potas. Oxide	6.55
Sod. Oxide	6.45
Sulphuric Acid	8.40
Loss by Calcination	23.60
	99.55

It is a compact mass, yellowish; concoidal fracture, formed in

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the nests and wedges of the syenite with considerable dimensions either vertical or horizontal.

There is plentiful supply of the rock or raw materal, aş the operatons so far have been primitive, and only the face of the hillside has been dug out and reduced. The alum bearing rock is brightly colored, usually with a pinkish or red tinge, and the waste from the Goynyk workings flows down to a small stream along the roadside; to these waters it gives a pinkih white and opaque color, incidentally kiling all the brook trout that happen to venture into the stained water from tthe higher part of the stream.

The operations are conducted by Greeks from the nearby villages. Wood for fuel, taken from surrounding mountans until they were denuded; it its now brought from relatively long distance.

The process of alum extraction is briefly as follows:— The rock or ore is first roasted and then broken into small pieces, which are very light because the chemical elements have been burned out. Fifty horseloads of 100 okes (282 lbs.) each of wood are required to burn 10 tons of stone in the furnace. The broken rock is then placed in open pits and allowed to be exposd to th rain and weather for a while.

From reliable source it is learned that the annual production of alum in this region is 2000 to 3000 tons. The alum extracted at Goynyk is said to be the strongest and most concentrated. Other workings are at Gotadza and Geliese, raw material yields 14.8% of alum.

Alum is consumed locally, and large quantities are shipped to Harpoot, Diarbekr, and the regions further inland. There seems to be no exportation to foreign countries. The principal use of alum is connected with the dying of cloth and yarn, the preparation of leather and medicinal purposes. Not the least important use is as a charm, a triangular piece being placed in a case made of silver, blue beads, etc. and worn about the neck of both human beings and animals. The price of alum at the mine is about 5 to 7 piasters per batman (7 lbs.) or 1¼ to 1¾ cents per pound, while in markets of Karahissar it retails for about 2½ cents a pound.

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The existance of this mineral is also reported from the Samson, Kerason, Tripoli, Trebizond, etc., occurring in the Tertiary syenites.

Alunite of exceptionally good quality is found at Saglik near Dashkessan in Gokcha range. It is found in Kidney formed concretions in trachyte tuffs of Turanian age. The occurances seems to be inexhaustible. The alunite contains 37.58% of alum and is free from pyrite and iron oxides. Occurances of less technical importance lie at Bechanak and in the Dary-dagh in the Daralagoz district.

LIMESTONES

Cretaceous white calcite occur extensively in both countries which is locally used for construction, lime and soap manufacturing.

ONYX: The beautiful banded and translucent spring deposit of recent limestine is known to exist in Pontus, in the Lower course of Halys, and Thermodon associated with jasper susceptible to take nice polish.

LITHOGRAPHIC STONE: The fine grained limestone, with imperfect concoidal fracture, gray and yellow in color, occur abundantly near Panderma. The output was controlled for some years by an English Syndicate. A good deal of money was spent without any result. The failure of the enterprise was attributed to the ignorance of Turkish customs and methods of dealing on the part of the management.

ARGILLACEOUS CALCITE rock occur extensively which may be readily used for cement manufacturing. The beds of this rock have never been exploited.

MARBLE: The compact type, crystalline, metamorphosed limestone occurs also extensvely in both countries. The rock is locally used for ornamental masonry. Its banded texture and the beautiful color due to the mixture of oxides of different metals has made it very desirable. According to the color it is locally called "white marble," "red marble," "yellow marble," "green marble," etc. The marbles and other metamorphic calcite rocks occur mostly in the vicinity of igneous rocks which is for this reason, called contact product of limestone.

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CHALK: The purest and the most white type of limestones is widely distributed over both countries. This natural substance could readily be used in paper, pigment and marking-chalk manufacturing if a good opportunity is created for the industrial development. No beds of chalk exploited, the marking-chalk is either imported from Europe and America.

GYPSUM

The sedimentary Tertiary beds of saline residue of gypsum occur extensively in the plateau formations. The efflorescence of gypsum are found along the saline lakes of Lycaonia, Lake Urmi, Lake Van, etc. The residual sulphate of sodium and carbonates are also found in the same saline regions associated with salt and little magnasium sulphate.

NITRATE

The beds of sodium nitrate is said to occur in saline regions associated with gypsum, borate, and also with volcanic tuffs, basalts and lake beds in volcanic regions. No attempts have been made for its exploitation.

CLAYS

Clays, of recent age, either sedimentary or residual, occur extensively in both countries. The ordinary red clay is used in local pottery and tile manufacturing.

FULLER'S EARTH: Every shade, from ray to dark green, occur everywhere which is used by natives in baths to clean the body from greese and other persperations. The beds of this natural substance could, in future be used for the cleaning of garments, deoxidizing, decolorizing and clarifying of fats and oils and in refining of petroleum.

KAOLINE: The purest variety of clay also occur in some places without any industrial application. The development of paper, paint, putty, crayon, china and pottery manufacturing will soon necessitate its exploitation.

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AGATE

In Asia Minor and Pontus, in the direction towards Kerasun and Trebizond, the agate, onyx and jasper is known to exist, which is still in the treasures of the famous Mithridate conquered by Pompius. The lower course of Halys (Kizil-semak) and Thermodon are furnished with these stones. Near Thermodon the port of Ounieh where extracted in the white and red calcareous rocks a bank of jasper susceptible to take nice polish.

SILICEOUS MARL

Spreading layers of white siliceous marl with 87.2 per cent silica, are found in about 5 cm. thick sheets at Kessatip not far from Akhalzik in Uraval Valley. A similar deposit of diatomaceous earth of Pleistocene age is found at Ilija near Erzerum.

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PART III.

METALLIC MINERALS

GOLD

Three major folded arcs, forming as many independent chains of lofty peaks, fringe the wave-battered shores of Asia Minor, and, encircling, rim-like, its elevated barren plateaus, determine the trend-lines of the structure of this westernmost projection of the Asiatic continent. Within the mighty folds of each, occurs an auriferous zone, genetically related to copious lava-flows of comparatively recent origin, detailed studies of which are yet to be made.

The Pontic gold-field lies in the most easterly, and the Anatolian gold-field in the most westerly, of these zones of disturbance, the effects of which have been so far-reaching upon the development and history of the peninsula. A third gold-field of altogether minor historical importance, lies on the slopes of the Tauric mountains, the most imposing of these three great uplifts.

This occurence within the only zones where heavy mountain-making agencies have been at work, of the only known gold producing areas in Asia Minor, can scarcely be regarded as a mere coincidence, though it would be hazardous, at this incipient stage of our knowledge of the geology of the region, to carry our generalizations too far.

ANATOLIAN GOLD-FIELD. This metalliferous province forms part of a geologic belt extending from the plains of Troy to the valley of the Pactolus, and slightly further south, so as to include Mount Tmolus—the modern Boz-Dagh. It contributed largely to the gold-output of proto-historic times, and, as might be naturally expected, it has been duly commemorated in various legends which have descended to us, together with the superabundant exaggerations with which ancient exploits were wont to be embellished.

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Its northeast portion was explored during antiquity in the vicinity of the Asiatic shores of the Dardanelles. The abundance of gold jewelry found in the excavations on the site of the several cities of Troy indicates a large production of gold from localities probably not far away. The best-known of these mining camps of the Troad flourished between Pergamos and Ataineos, and were inhabited by the Dactyles, a hardy and enterprising race. Strabo, in the course of his travels, found numerous traces of ancient workings in the vicinity of the ancient town of Astyra, then a ruined city which formed part of Abydos, but which has been independent when the gold-mines in its vicinity were productive. At the time of Strabo's visit, close to the dawn of the Christian era, the mines had been practically abandoned, and the formerly prosperous mining-camp had dwindled to commercial insignificance. The extent of the ancient workings seen by him indicates that mining had been carried on very actively at this point, and legendary tales often attribute the immense wealth of Tantalus or of Priam to the ownership of these diggings.

The site of Astyra is supposed to coincide with that of the modern hamlet of Serjiller, about 14 miles south of the Dardenelles. Abandoned workings of considerable extent are known to exist at this point, in a mica-schist country, intruded upon by lower Tertiary igneous rocks, which according to Diller, English and Flett, consist of liparite, mica-hornblende, and augite-andesites, the latter is an advanced stage of decomposition. All these volcanic rocks have been ultimately capped with basalt. This igneous series is remarkably similar to some which have been observed in various zones of volcanic activity within the great American Great Basin region, such as the southwestern portion of Nevada, where appreciable amounts of gold have been yielded by veins incased within rocks, the chief characteristic of which appear to consist in the intermediate composition, in a scale of decreasing acidity of the magmas from which they have solidified.

A portion of the large quantity of gold articles unearthed on the site of Troy must have been derived from Phrygia and Lydia, two of the most important mining-provinces of the world in the first millenium B. C. It may be recalled here

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that the Troad borders on Phrygia, where, according to ancient traditions, the discovery of the art of fusing metals took place in the course of a forest-fire, during which it was found that fragments of ore had been accidentally melted.

There cannot be any doubt that the Phrygians, in common with their better-known eastern neighbors, the Lydians, were the most renowned miners and metallurgists during the pre-eminence of Hellenic culture. The profusion of mineral species, enumerated by Pliny as found in these kingdoms, indicates that the natives had abundant opportunities to become proficient in the arts of mining and smelting.

Lydia especially was renowned for its wealthy rulers and citizens, most of whom were owners and operators of mines. Sardes, the capital, was long a world-market for gold, silver, copper, and iron. Not only did the Lydians derive large incomes directly from their underground operations but, being situated, geographically, midway between Western culture and Eastern splendor, they managed to act as commission-agents for both parties, so that products from either direction paid them toll in transit, and thus increased the wealth of the Lydian capitalists. Herodotus mentions the colossal, forunte reaching far into the tens of millions of dollars, amassed by Prince Phthios, supposed by some to have been a descendant of Croesus, the wealthiest of the kings of Lydia. This nobleman was the dynast of Celenes when Xerxes invaded the West. Plutarch declares that it was his custom to prevent the inhabiants of the mining-districts under his rule from pursuing heir agricultural labors, lest the time thus spent be subtracted from more profitable employment at underground work. We can more easily understand such conditions when we take into consideration the great scarcity of metals, and the consequent demand for them,, which existed at that time throughout Europe. The lack of gold was particularly felt in Greece in the sixth century B. C., when the Lacedemonians had to import expressly from Lydia the relatively small amount required for the gilding of a statue. With regard to the wealth of Croesus, Rawlinson, referring to Strabo, says that its reality cannot be questioned; for Herodotus had himself seen the ingots of solid gold, six palms long, three broad and one deep, which to the number

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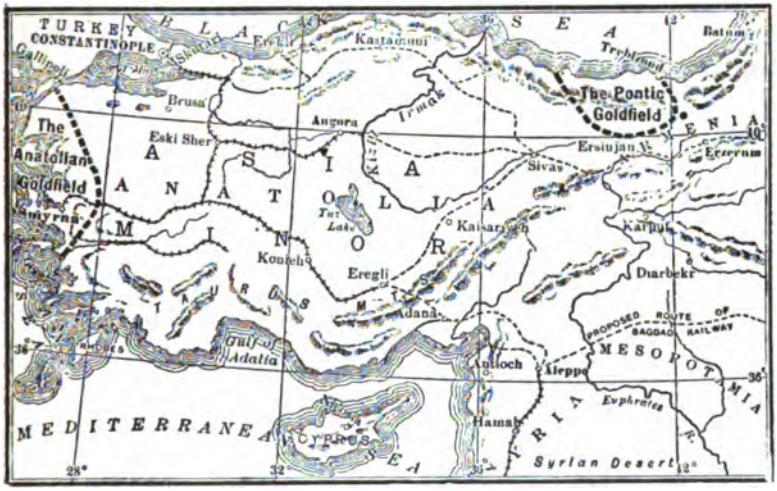
of 117 were laid up in the treasury at Delphi.

The height of Lydian prosperity was attained in the first quarter of the seventh century B. C. and successfully maintained during the ensuing 250 years. Throughout this period the precious metal was won both from alluvial and from deeper mining. Glowing tales concerning the gold-producing banks of the Hermos were spread to the confines of the world; and many are the legends that spring from the accounts of the rich clean-ups made by enterprising Lydian prospectors in washing the gravels of the Hermos and its tributary, the Pactolus. The latter stream owed its gold, according to an ancient story, to the fact that Midas, the mythical founder of the Phrygian kingdom,



MAP REPRESENTS THE ANCIENT GOLD FIELDS OF ANATOLIA AND PONTUS.

had bathed in its waters, upon the advice of Bacchus, in order to be deprived of the fatal faculty of turning everything he touched into gold. This tradition, like so many others of a kindred nature, has value only as indicating the existence of an ancient and flourishing placer-industry in the valley of the Pactolus. This river, as well as the Hermos, of which it is an affluent, rises on the northern slope of the Tmolus mountain, itself the site of numerous mining excavations. It may be safely assumed, as an

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explanation of these old workings, that the discovery of nuggets in the river-sediments stimulated a careful examination of the immediate vicinity and that this search led the ancient prospectors to the ultimate source of the gold, namely, to the auriferous veins of the mountain.

How prolific in their yield of the precious metal these banks of the Pactolus must have been may be inferred from a partial review of the frequent allusions in ancient literature to the gold-bearing sands of this famous river. Tchihtchaff's enumeration suggests the strong appeal made by this source of wealth to the imagination of ancient writers. Among others, Scylan of Caryadnis speaks of the Pactolus as having formerly borne the name of Chrysoras (the gold-bearing), by reason of its auriferous character. He claims, furthemore, that the precious element was engendered eternally in its waters. Herodotus also alludes to the gold carried by this stream; and it is interesting to note that he lays special stress on the notion that the gold was primarily obtained from the flanks of Mount Tmolus. Poets and writers in endless succession have extolled the good fortune of the Lydian prospector. Virgil, Juvenal, Sivius Italicus, all refer in glowing terms to the gold-laden muds borne along with the flowing waters. Seneca, with wonted emphasis, describes the river as inundating the fields with gold (inundat auro rura).

Nevertheless, this production was not destined to be everlasting. In Strabo's time, at the beginning of the Christian era, it had dwindled to comparative insignificance. Philostrates quotes Appolonius as saying that the Pactolus was "formerly" auriferous; and, inasmuch as this celebrated philosopher was a contemporary of Nero and Vespasian, it may be inferred that very little gold was recovered from this source at that time. The same writer advances the hypothesis of the primary derivation of the nuggets from the very rocks of Mount Tmolus, and his assertions in this respect indicate a remarkable soundness of deductive reasoning. In the light of modern theories on placer-formation, a part of their metallic contents may well have been derived from the rocks incasing the veins which, in the course of their erosion, have contributed the bulk of the metal subsequently redeposited in the form of nuggets.

A later writer, Festus Avenius, makes use of the term "auriger"

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in the text of a description of this affluent of the Hermos. His use of the adjective need not, however, be taken as indicaitve of a renewed activity of mining on the Pactolus. It may have been employed by way of reminiscence only. Such, indeed, appears to be the case in the writings of Constantine Manasses, a Byzantine writer of the eleventh century; and John the Lydian, a native of the valley of the Hermos, alludes to the Pactolus merely to refer to its past contributions to the world's wealth. In our own time, peasants dwelling in he vicinity of Boz-Dagh are known to make a scanty livelihood by washing the gravels brought down by the rivers. But their appearance and mode of living are far from supporting a belief in the continued abundance of the yellow metal in that region. It is therefore possible that the placers of this gold-field were exhausted fifteen centuries ago, although the same assertion might not be made with regard to the original sources of the nuggets discovered by the ancients.

The ambition of these early Greek miners was not confined to alluvial mining. Numerous deeper workings have been found on the slopes of Mount Tmolus. Farther north and in a similar direction from the bay of Smyrna, similar vestiges of ancient labors are to be seen on Mount Sipylus—the modern Manissa-Dagh. Thomae, speaking of gold-ores in the vilayet of Aidin, refers to this locality as one from which part of the wealth of Croesus was derived. He says the ancient workings had not been fully fathomed, although a vertical depth of 200 ft. below the crown of the hill has been reached. The same observer calls the country-rock in these mines a trachyte, which he found to be very much decomposed in the upper levels, worked by the Lydians. Small veins, cutting across the same volcanic rock, were found to carry argentiferous galena blende, copper, and iron pyrites with gold, all with a quartz gangue. An average sample taken from a 1 to 2-ton lot of ore, assayed as follows: Gold 13 dwt., and silver, 5oz. 13 dwt. Troy per ton; lead, 7.6 copper, 2.2, and zinc 2.7 per cent.

The Lydians could fairly claim to be the first users of coins in history. This, in itself, bespeaks the abundance of the precious metals in that richly, endowed country. It was quite natural that accumulations of gold and silver should eventually be bartered for commodities brought from all over the world to this

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meeting-point of the East and the West. To stamp the metals with distinctive signs, and use them as a measure of value, was the next step, and an easy one in the ordinary course of commercial transactions.

The earliest products of the Lydian mints were issued during the seventh century B. C., and were made, not of pure gold or silver but of a compound of both, known as "elektron," in which the ratio of gold to silver was four to one by weight. The name is supposed to be derived from the identical Greek word, designating amber, which the native alloys of those metals somewhat resemble in color. A century latter, gold and silver coins appeared; and, no doubt, this change was associated with the discovery of a method of parting the two metals. Gold and silver generally occur in nature in alloys of various proportions, the character f which is particularly evident where the veins containing them are the ultimate manifestations of volcanic activity. The Anatolian gold-field, for instance, belong to such a region of vulcanism, where gold-bearing veins, occuring in igneous rocks, carry a noteworthy amount of silver. But, apart from all extreme manifestations, the general phenomenon is, that metallic gold occurs in nature generally alloyed with silver (and not with copper.) So universal and so well-recognized is this phenomenon, that the distinguished mineralogist, Breithaupt, Professor of that science at Frieberg, classified native gold and native silver as one species, ranging in composition from gold with a trace of silver to silver with a trace of gold, and denied the occurrence in nature of either metal without some alloy of the other. The proportions of the two metals in native alloys vary with the composition of the minerals from which they have been reduced. It seems probable, therefore, that the "elektron" of the Lydians was simply the native alloy characteristic of their own district, and was adopted for coinage and commerce until the discovery of a method of parting permitted the manufacturer of gold and silver coins separately.

PONTIC GOLD-FIELD. In the northeastern portion of Asiatic Turkey, and at the point of junction of three empires, the snow-capped peak of a huge Tertiary volcano, familiarly known as Mount Ararat, rising in majestic loneliness above all surrounding eminences, marks the center of a region characterized by re-

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peated concanic eruptions, and the point of intersection of two main axis of high uplift. One of the latter sweeps westwardly, to form a long mountain chain which borders all the northeastern shore of Asia Minor, and within which gold-mining has been actively carried on since proto-historic times.

An interesting clue to these very ancient operations is afforded by the text of a portion of the second chaper of Genesis (vv. 10-12):

"And a river went out of Eden to water the gardens; and from thence it was parted, and became four heads.

"The name of the first is Pison; that is it which compasseth the whole land of Havilah, where there is gold.

"And the gold of that land is good; there is bedellium and the onyx stone."

By many Bible students, the river Pison has been identified as the modern choruksu, running generally parallel to the east-west extension of the coast. Its valley has been since time immemorial a region of exceeding fertility, and has also enjoyed, thanks to the sheltering barrier formed by the elevated Pontic range along the northern bank of the river, the added blessing of immunity from the ravages of the bleak northern gales of Russia. It is not surprising that the combination of such advantages awakened desire for their possession in ambitious leaders of different periods; and many are the tales of struggle and bloodshed over the ownership of these gold-fields.

One of these stories is repeated by Strabo, whose explorations of the then known world at a time when traveling was beset with innumerable difficulties, have made his name illustrious among students of the geography of antiquity. It appears that Alexander the Great, perhaps remembering his father's successful mininm-ventures in Macedonia, received intimations of the abundance of gold in the sambana district, which lay in the province of Syspiritides (the modern Ispir), within the Pontic productive area. Straightway he dispatched Menon, one of his generals, at the head of an armed force, commissioned him to secure possession of the wealth-yielding territory. The sturdy natives, however resisted the great conqueror's designs regarding lands which they justly regarded as their own, and having

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routed the invaders, sent back to Alexander the head of Menon, his general.

Some ieght ceituries later, gold-mines south of the harbor of Trebizond, in the same district, became the subject of dispuite between Justinian, the mighty Byzantine emperor, and Chosroes, the King of Persia, his foe. At that time the workings, operated on a very extensive scale, were furnishing abundant supplies of the precious metal for the mint at Constantinople. Much of this gold was won from placers along the banks of the Tchoruksu and its tributaries, the latter having their sources in the southern facets of the Pontic range.

Strabbo's copious notes here become again instructive. He says that the natives recover gold by first straining the auriferous muds through screens and subsequently spreading the undersize over sheep-skins specially selected on account of their long fleece, the shred of which serve to entangle the particles of metal. Incidentally, it may be noted that the derivation of the appelation "Land of the Golden Fleece," by which this northeastern portion of Asiatic Turkey was designated in the oldest tales of the Greek mythology, becomes self-suggestive. The corroborative testimony supplemented by the name of Cape Jason, applied to a nearby promontory, tends to remove all shadow of doubt regarding the exact location of the once-famous Eldorado.

The period of its original discovery, however, cannot be determined as closely as its location. The earliest known record is the mythical narrative of the Argonauts in search of the Golden Fleece; and this story yields but a single credible fact—namely, that, at some time in early Greek history, not unlikely about 1000 B. C., yet perhaps a few centuries later, a band of adventurous Greek immigrants decided to set forth and discover the country from which they had received from time to time reports of the existence of untold wealth in various forms.

There is no doubt that, from that time on, and far into the fifth century B. C., the various Greek communities were actively engaged in the exploration and colonization of the regions lying east of their mainland. Such expansions in the course of the national growth have invariably been the consequence of prosperity at home. It is not inconceivable that some of the hardier and more indefatigable of these explorers surmounted the hard-

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ships attending travel on the turbulent waters of the Black Sea, and succeeded in reaching portions of its southeastern shores. What they saw there may be inferred from tales which they brought back, enriched with the adornments required to fire the imaginations of their countrymen.

According to the version of Pliny, Strabo's younger contemporary, and one of the best known naturalists of antiquity, the Colchis, as he calls the Land of the Golden Fleece, was ruled, previous to the coming of the Argonauts, by Selances, a descendant of Actes. This ruler is said to have discovered extensive gold-placers in the territory inhabited by the Suanes, who lived within the pale of the Colchides. "The whole country, however, is renowned for its gold-fields," is Pliny's final comment in connection with this description.

TAURIC GOLD FIELDS. Gold-bearing quartz veins have been discovered in the Bulgar-Dagh range, in southern Anatolia (Cilician Taurus). The gold here occurs also associated with the argentiferous-lead ores yielding 30 to 40 grams per ton.

At Harpoot, in Armenian Taurus, alluvial gold has been found in Khutel-dagh and Kilvenek on the banks of Murad.

Abundant gold mines lie in Shirvan Mountains, south of Lake Van.

In the sands of Chorokh River and in the districts of Batum and Sasun gold is found associated with platinum.

Alluvial gold is found now in the tributaries of lower Chorokh. There it is associated with palladium, rhodium, osmium, and Irridium, all of which arises from gold bearing copper gravels and serpentine rocks.

The gold in the alluvian of Aliaji streams (west Karabagh) reaches an amount, namely, 0.264 grains per ton. It arises doubtless from the west Karabagh chain; far from Agarak there is a piece of electrum which contains 72.22 per cent. gold and 22.2 per cent. silver.

A little gold has been gotten from the copper ore of Kalakent and in the hornblende diorite which intrudes the Nummulite lime.

This precious metal is also recovered as by-product in the extraction of other ores. The descriptions of which will be found under respective headings of the copper, argentiferous-lead, and arsenic as occurring associated with these ores.

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FUTURE PROSPECTS. To our own generation the point of interest in connection with any of these gold-fields lies in the possibility of a resumption of exploitation of the hitherto abandoned workings. This does not necessarily imply that gold will again be the chief metal recovered. These have been numerous instances where mines, at one time gold-producing, have eventually turned out to be great producers of copper. Two noteworthy instances of such a sequence are furnished by two of the world's largest present deposits of low-grade copper sulphides: the Mount Lyell mine in Tasmania, and the Rio Tinto in the Spanish province of Huelva. The former came into prominence in 1881, and began to attract attention as a gold-producer in the incipient stage of its development. With regard to the latter, Strabo, to whom frequent reference must perforce be made in connection with ancient mining, has given us an enhusiatic account of the gold-production in southern Spain on the site of what are now the famous and immensely productive copper-mines of Rio Tinto.

Another instance of the same nature occurs at the Mount Morgan mine in Australia. Here the ore at very shallow depth was rich in gold and carried only insignificant quantities of copper. Lower down, however, the percentage of the latter metal grew considerably higher.

There are some signs of the recurrence of the same phenomenon in the Pontic gold-field. Copper has been mined during the past few centuries at various points within this metalliferous province. Although these operations have been desultory, there is ground to suspect the existence of a rich copper-belt parallel with the northeastern coastal development of Asia Minor. Kerassons is, among others, a noteworthy locality in which copper-ores in large bodies have been reported on various occasions. The recovery of gold as a by-product in the smelting of such ores is by no means impossible.

Work on the Anatolian gold-field, on the other hand, has remained practically at a stand-still since the beginning of the Christian era. Perhaps detailed investigation of the region will lead to interesting industrial developments; and, while these ancient gold-fields may never again yield such quantities of the precious metal as they gave to the miners of antiquity, they may

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produce, through development of lower depths, of the baser metals, a greater treasure than they conferred on former generations.

ANNUAL GOLD PRODUCTION.

Years	Kilos	Worth in dollars
1891	10	7000
1892	10	7000
1893	10	1000
1894	12	8000
1895	12	8000
1896	12	8000
1897	12	8000
1898	12	8000
1899	12	7975
1900	11.6	7751
1901	11.6	7751
1902	20	13292
1903	31	20607
1904	31	20607
1905	43.5	29000
1906	44	29,000

SILVER.

In Anatolia and Armenia there are many old silver mines, but nearly all of them are idle, not because they have been exhausted, but there was no inducement to work them under existing government.

Silver mostly occurs associated with lead and zinc. Considerable amount of silver is also extracted from gold mines. The chief mines of Argentiferous-galena exist in the provinces of Trebizond, Erzerum, Diarbekr, Adana, and Hudavendighar.

Gumush-hané, near Trebizond, is probably the richest of these and has produced lead and silver since remote times. This locality of Argentiferous galena has been considered like a School of Mines of Constantinople, and a tentative object of recent resumption.

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Following the old descriptions of this mine, given by Hamilton and commented by Tchihatcheff, here Tertiary and Cretaceous limestones, marls and the chalk formations are penetrated by granite rocks, and both the chalk formations and the granite are crossed by veins of silver bearing galena. But the ore is richer in the eruptive rocks. Hundred grams of extracted silver yields 4 grams of gold.

Bakr-Kuressi, on the south of Ineboli, has been a famous locality on account of its argentiferous copper mines.

The district of Kara-Hissar is also known to be rich in silver ores, and two foreign companies have acquired rights there since 1880. The Asia Minor Company have had a concession concerning six square miles where 20 veins have been located and some development done. The veins are chiefly found in the andesite and carry argentiferous galena. One of the mines opened has a vein 2 meters thick on which several levels have been run. The best ores carry about 70 per cent. lead, with from 1.5 Kg. silver to the ton. Most of these discoveries have been based on the ancient workings. The workings are not being extended.

In the Derekoi Valley, in the same district, there was also a concession granted for 99 years to an English company. This covered 24 sq. miles. Exploration had shown several veins existing in andesite and porpyhry, carrying lead, silver and sometimes little gold.

At Katirlan three veins have been opened and some development work done. The concession was granted in 1871, and work was carried on to 1883, when it was suspended. It was resumed in 1892, but has lately been again stopped. The same company worked the mines at Keshab.

Silver mines have also been worked at Sivas and Avanos.

In Khortakal, near Ispir (south of Chorokh river) a rich argentiferous galena is exploited which outcrops in Baiburt, between Trebizond and Erzerum, in the same basin of Chorokh on the west.

About 20 km. southeast of Baibourt is found Maden-Khan mine which occupies an area of about 400 M. It is in the vicinity of green rocks crossing Lower Cretaceous formations. The copper is also associated with these rocks.

In the valley if Imerkhim, near Artvin, and further south,

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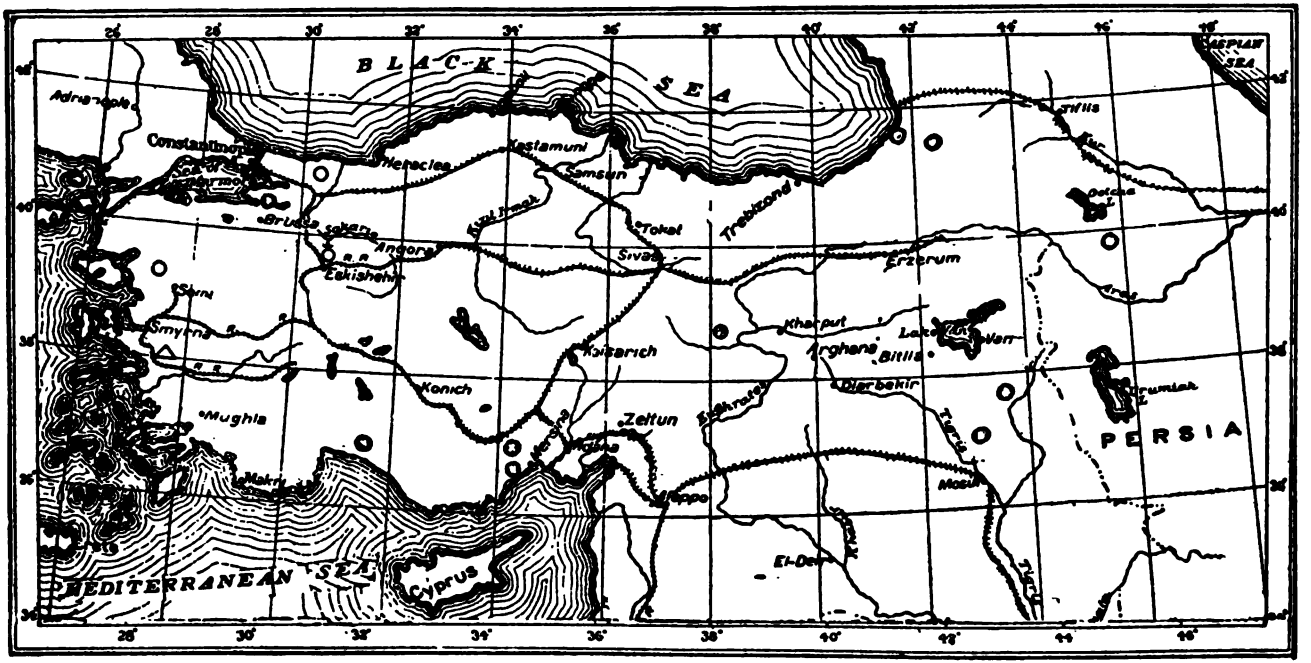

THE LOCATION OF THE MOST IMPORTANT SILVER-LEAD-ZINC DEPOSITS OF ARMENIA AND ANATOLIA.

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in Khordalan, the argentiferous lead is found associated with copper, zinc and with little manganese and traces of gold.

Going back to the west, on the western bank of Kizil-Irmak, following a meridional zone, we find the argentiferous lead mines at Denek-Maden, which is since long time, abandoned.

Toward the north, Karahissar presents a silver mine, mentioned sometimes by Barth. Further to east on the west of Sivas and Akdagh, between Amasia and Kaisarie, and interesting galena deposit associated with pyrite, found in crystalline calcareous rocks, alternating with mica, schists and amphibolic-schists, traversed by granites. The minerals in the vicinity present a mass which on the surface, is filled with oxide of iron and pyrite, with ochreous matters, and associated with calamine which does not outcrop nicely.

Kebban Maden.—About 18 miles west-northwest from Kharput, a group of limestone mountains fills up all the space intervening between this point and the Euphrates to the north and west, and through these a deeply cut valley runs to the north-

GEOLOGICAL VIEW OF SILVER MINE AT KEBAN.

west extending for six or eight miles to the Euphrates, where for some distance around the point of confluence are worked the silver mines of Kebban Maden. The mountains around the silver mines exhibit in general bare surfaces of gray, compact limestones, or of argillaceous and chloritic slates, both of which appear to be without fossils. On both sides of the valley in which the town is situated, rise sharp peaks of a hard feldspathic porphyry, containing large crystals of pink common feldspar and sometimes exhibiting a slaty texture with the crystallized parts so ill defined that where it occurs in contact with the clay slates

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it is difficult to assign to each its proper boundary. This eruptive rock also makes its appearance more frequently in the bottom of the neighboring valleys. A sharp ridge of the same rock along the back of the east side of the town and there forms bold precipices facing the river which flows almost beneath. A little farther to the north the porphyry is interrupted by a band of ochreous matter which probably before the formation of the valley of Kebban communicated with a similar patch on the opposite side, forming a lode or dike. The surface of hills as well as here and there on the opposite side of the Euphrates are covered with innumerable rubbish heaps formed in attempts to open mines which have already been pushed more than two or three feet in the ground. The mines worked lie beyond the ridge on the west of the town and are even more miserably directed than those of Arghaneh. The edit mouths are driven through shale and limestone which here and there shows on the surface small strings and lumps of galena; but so irregular and dirty are the works that little can be seen underground to inform us how the ore occurs. The lower mines exhibited some rich portions of nearly pure argentiferous sulphuret of lead but it nowhere had the appearance of occuring in veins. In the upper mine, a large quantity of soft iron ochre, or sort of gossan mingled with threads of gypsum, is excavated as ore, being found to contain like the galena from an ounce to an ounce and a half of silver in 100 lbs. Near the junction of two species of rock, whether limestone or shale, or one of these with porphyry, the ore is more plentifully disseminated than elswhere.

This is a complex deposit of Argentiferous galena, blende and pyrite with antimony. In higher parts the sulphide and the chloride of silver, anglesite, gypsum, etc., exist abundantly. This mine had been exploited by German engineers in 1847 and abandoned soon after.

Bulgar-Maden.—The Bulgar-Maden lies in the Cilician Taurus sixty-five Km. north of Mersina. The beds toward the south are sligtly inclined containing no eruptive rocks; but toward the north occurs many plicated eruptive rocks which are followed by microgranulites, porphyrites of relatively ancient origin, Cretaceous-Eocene serpentines, and Tertiary discharges, extending toward north, in the Argeaus mountains.

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The stratified series starts with the schists in glaucophane, succeeding he calc-schists and dolomitic calcareous rocks the age

S
Diluvium of Tarsus plain
Bulgar-Maden
Kedi-Kaya
Kedi-Kaya
Kedi-Kaya

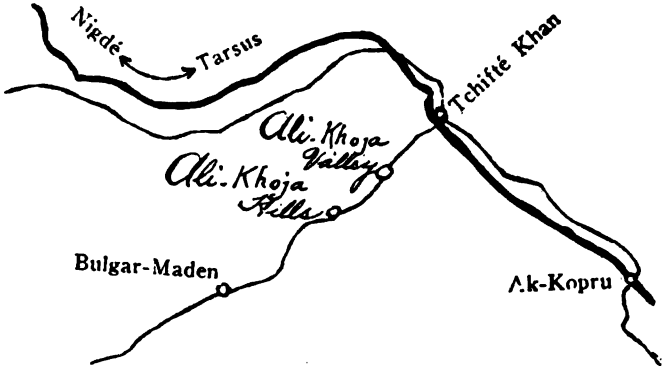
of which is not exactly determined. Briss includes them in the devonian of Anti-Taurus.

The central calcareous rocks of the chain presents all the characters of coral reef formations. On the north it becomes more marly and much more stretched in the action of ebbing, and sharply folded with ruptures.

To the Devonian axis is applied the Tertiary formations on both sides, showing a distinct undulation in the dolomitic calcareous rocks. The Hercyenan Movement is here obvious, same way as in the Alpian chains.

These Tertiary deposits include in the Miocene gypsum the Lower Eocene Nummulitic beds, the sandstones on the north, the Oligocene marly calcareous rocks on the south. Thus the dissimilarity of Eocene rocks on both sides gives clue for the existence of two separate seas of distinct sedimentation

Toward the northwest the dolomite and porphyrites of Ylang-dagh rise up against the folded Tertiary rocks with a fault following the abundant sources of the thermal of Elidja. Near Nigdé the Tertiary beds are folded, like those on the south, in a slight degree. These roll down towards the plains of Great Salt Desert, and disappear under the lavas and dolomites ofnortheast, or under the Pliocene sediments.



GEOGRAPHICAL LOCATION OF BULGAR-MADEN.

The Bulgar-dagh mine is geographically located in a valley, the road of which is opened from Chifté-khan, at the junction of main road leading from Nigdé to Taurus.

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The hills upon the north flank of the mine, presents the Devonian dolomitic calcareous rocks overlying the schists and nummulitic grits. The calcareous rocks are traversed by microgranulites playing a great rôle in the dislocation of these metallizing waters. These microgranulites form irregular veins, either round or lenticular, in the calcareous rocks. The serpentine rocks of Eocene age appear in different points in the ordinary condition of the formation.

The primitive form of metallization is difficultily visible; because the beds are subjected to an extensive alteration.

The metalliferous formation extends about 100 km. up to the contact of calcareous rocks with Eocene schists. The schists are traversed by serpentine from which the minerals are derived according to Briss.

Beyond this contact of calcearous rocks with schists, there is same way, a contact of calcareous rocks with microgranulites which is characteristic phenomena observed in the ore bodies of Leadville, Colorado. The zone of this microgranulite is pursued in all extension in the metallic formation of Bulgar-Maden. Some masses of minerals are filled in the pockets of this microgranulite which miners call *Beyaz-tash* (white stone).

This is a bed of contact which is subjected to alteration below the level of the valley. This change, according to Briss, is due to subterranean circulating waters, in contact with metallic sulphures. The traces of many subterranean rivers, ,now dried, are still there visible.

The deposit, situated on an altitude of about 2000 to 2400 meters, is divided into two zones. The first, (galleries of Serusat, Tnoallé, Yourkanji, Teki-deresi), approached by the axis of the mountain and is deep-seated, and less altered. The more compact limestones are more replaced by galena. The second is exterior and more superficial and offers big grots. The soil in grots represents a sandy and muddy deposit of lead carbonate mixed with red, yellow, and black oxide of iron. The pockets in calcareous rocks are filled with metals, accumulated without any order. There, it exists in a series of natural halls, and in arches furnished with stalactite of calcareous rocks, and covered with a recent and contemporaneous transparent crust of carbonate of lime.

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The deposits, in this special natural phenomena, are extraordinarily rich in lead, silver and gold. Aicording to Briss, the medium tenor of ore contains 20 per cent. lead; 65 Kg. silver and 30 to 40 gr. gold per ton of lead. This tenor of gold gives clue for the existence of pyrite from which the iron oxide is produced.

The argentiferous-galena is exploited in Bereketly-Maden, in the vicinity of Bulgar-Dagh, on the north east of Arpa-Ouch-ourou, in Ak-dagh, extreme west of Ala dagh; in Farach or ourou, in Ak-dagh, extreme west of Ala-dagh; in Bulgar-dagh and Mount Argeas; in Gulek, south of Bulgar-dagh. Here, deposits of lead and silver are found in a system of calcareous rocks alternating with talc-schists and serpentine which according to Tchihatcheff they belong to Eocene.

The exploitation of argentiferous-auriferous lead of Bulgar-dagh is conducted by many specialists but the developments have been made in a very rudimentary way, without any plan, with imagination, and absolute inexperience. Turk government has never followed the advices and directions given by French engineers, and the extraction was soon suspended. The extraction attained to about 2000 tons in 1892.

This mine was Turkish state property, has some mining so far little developed in the argentiferous cementation zone. The bed stretches for some 20 Km. in length and lies only 16 Km. as the crow flies from the Baghdad railway.

Silver-lead of Hudavendighar.—The deposits of the district of Mysia have been investigated by many mining engineers for a long time. The direction of the beds is to north-east and extend from Smyrna to the Sea of Marmora. The essential zone of metallization of silver seems to be augite-andesite rocks in contact with limestones. According to the observations of Messrs. Weiss and Berg this contact had not only played here a physical rôle like the schists and calcareous rocks of Thasos, in Laurion, in Sardaiga, but andesite growth has occasionally developed in the embedded calcareous rocks, a gangue of granite, angite, epidote and anorthite, among whose the metallic sulphur is crystallized contemporaneously.

All theories on the origin seem incontestibly to be a Tertiary metallization, because it is posterior to andesite.

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According to the descriptions of Messrs. Weiss and Berg, the metallic sulphur and silica are developed in contact with augite, andesite, and carboniferous calcareous rock, in a zone from 2 to 5 meters large. A similar case is observed by Bukowski in the great part of Greek Archipelago and in Thrace. Along this contact zone the calcareous rocks have undergone metamorphism and have been silicified. The microscopic examination of this rock made by Berg, shows well the original association of sulphur with the metamorphic minerals. The limestones are afterwards replaced by silicates a very small proportion of which hardly shows the following order of consolidation: first epidolite, second, garnet with pyrite, third, anorthosite with galena. The metallic sulphurs are developed in nests or masses, in the vicinity of the contact, either in calcareous rocks or specially in the same andesite, where it has met with some good nests in the fissures, in which they follow a columnar structure. Sometimes a pocket of very hard and compact galena is found embedded in the andesite, 26 meters long, from 3 to 5 meters wide, and 6 meters deep. After Weiss is found a galena of columnar structure and many meters thick.

It is observed that the case is most favorable in those places where the calcareous rocks lie below the andesite. This contact is frequtntly marked by a kind of argillaceous and brecciated residue (salbande) which acknowledge the posterior sliding.

In the entire system of the deposits manganese also occurs near the contact of augite andesite, with calcareous rocks. This in relation with the calcareous formations, sometimes attain to 100 meters in size. It proves mostly the superficial alteration. The pyrolusite is mixed there with the argillaceous residue of the dissolution of calcareous rocks.

Balia-Maden.—The best developed silver-lead mines of Hudavendighar province occurs near the town of Balia, at a distance of about 100 km. from the Sea of Marmora. The ore occurs in a contact-zone between Tertiary augite-andesite and Carboniferous limestone. The contact zone varies between 6 and 16 ft. in width. The limestone at the contact is silicified but barren. In the andesite, on the other hand, are found accumulations of pure galena which seem to be connected with fissures parallel to contact zone. The ores carry galena, blende, and py-

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rite, and contain on an average from 16 to 20 per cent. lead and 8 per cent. zinc.

The plant at Balia comprises a mill of 400 tons daily capacity for the production of lead concentrate, and a Wetherhill magnetic separator for making a blende product. The smelting works are provided with a water-jacket lead-furnace of rectangular section, 1 by 1.8 meters, of 100 tons daily capacity. The slags produced contain 20 per cent. lead, 20 grains silver, and 10 per cent. zinc per ton.

In 1903, the mine output amounted to 63000 tons, yielding 7600 tons of pig lead, with an average content of 97.5 per cent. lead and 1950 grams silver per ton. Output in 1913, 13076 tons of crude lead and 5000 tons of zinc ore, with 42 per cent. zinc. Amount of ore shown by the latest exploration, made by Germans (information from Gen. Beyschlag, 1919) 300,000 to 350,000 tons; further explorations may show more.

The pig lead is transported to the coast, whence it is shipped to Frankfort in Germany for refining. Besides the lead product, about 200 tons of zinc concentrate, assaying 41% zinc is produced annually. The company owns and operates the lignite coal mines at Manjilik. Here an electric power station has been installed. Generators having a total capacity of 700 horsepower produce the current, which is transmitted to Balia and the mines. The smelting coasts, including preliminary roasting, are about 60 francs (11.40 dollars) per ton of ore treated. Milling costs amount to 3.8 francs (72 cents).

South of Kurmasti, two deposits of silver-lead ores are known, at Dumbeltek and Kesikderé. An inspection of the abandoned working at this point reveals geological conditions similar to those observable at Balia.

About 25 km. northwest of Soma there exists a district from which, according to reports, galena float has been found in assocation with blende and calcopyrite. The ores occur in decomposed andesite, a kind of stockwork containing veinlets of calcite and barite, from 1 to 5 meters large, where exist the galena, cupriferous pyrite and pyrite. The rocks composed of some lenticular quartz and braunspath with galena and blende 5 meters wide 30 meters long. On this point has never been made a tentative exploitation.

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A very similar bed exists at 6 km. south of Beigerlerkoi, equally galena and blende with barite in trachyte.

At 10 km. distance from Perghama an antique work carries argentiferous galena, with masses of calamine. Some galena and cupriferous pyrite are forming pockets or tracing the columns in calcareous rocks in the vicinity of a trachyte in the same conditions as in Balia-Maden.

At 45 km. distance from east-southeast of Broussa, 3 km. from Hairié, a region represents antimony, a pyriteous mass of 10 meters large, embedded in the calcareous rocks, containing a little disseminated cupriferous pyrite. Not very far from there, in calacareous rocks exists two beds of pyrite with galena, interstratified in a series of calcareous rocks and schists, intercalated one between the porphyry, the other between the porphyry and calcareous rocks.

Towards east, between Nicié (Isnik) and Isnik-cheir, near Kerasliyaila, the veins of quartz carrying pyrite, galena and a little cupriferous pyrite are cut in open air; these are intercalated between the decomposed porphyry. These veins are very poor.

ANNUAL PRODUCTION OF SILVER.

Year	Value	Kilos
1891	$55,000	1,323
1892	55,000	1,323
1893	159,236	6,334
1894	30,000	1,516
1895	33,821	1,516
1896	32,821	1,525
1897	29,314	1,515
1898	28,927	1,525
1899	38,900	2,033
1900	40,139	2,033
1901	38,531	2,033
1902	250,577	14,942
1903	250,305	14,566

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1904	345,420	17,022
1905	367,351	17,107
1906	367,351	17,107
1909		7,791
1910		7,791

COPPER.

The provinces of Trebizond (Pontus), Caucasian Armenia, and Diarbekr are for a long time known as the best localities of rich copper deposits. The copper ores of Trebizond form naturally the continuation of the Caucasian deposits.

On the south of Ineboli, an ancient mine of argentiferous copper, in Bakir-Kuressi, has been famous since ancient times.

Six different properties have been operated in the vicinity of the sea-port of Sinope.

Traversing the course of the Kizil Irmak, we find, on the south of Kerasun, a group of ores composed of veins of various fillings, generally embedded in the crystalline schists. Among these are the copper mines of Maden-Koi, Gelivera, Sarababa, and Ispie. At Ispie important exploration is being conducted on a copper concession thickly studded with old workings. They are controlled by an Anglo-native Company. The ore bodies were worked superficially 800-900 years ago. Within the cast of 25 years, French and English syndicates have done considerable development work on these properties.

Little further toward east and on the south of Trebizond, a high grade copper ore is reported from Maden Khan, from vicinity of the towns of Gumushkhané and Karahissar. In this district the ore exists in the form of veins with copper gravels and pyrite, silver bearing galena and sulphate of zinc which cross a propylitized augite-andesite. Here and there are volcanic tuffs impregnated with copper gravels and which contain concretions rich in sulphate of zinc (39 per cent). In other cases there are contact conditions involving sulphides (copper gravels, pyrite and tremolite) in masses of Cretaceous limestones which have been engulfed in eruptive rocks.

Archavatal is one of the most important centers for getting copper and manganese. Old rocks are plentiful here.

In the Artvin district south of Batum the mines of Zangul

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and Ergha have been worked with success. Here are veins and masses of Granophyr passing to a diabase porphyry in a certain sandstone and both rocks are penetrated by numerous quartz veins which contain irregular ore bodies of different sulphides, especially those of copper and iron associated with lead carbonate and still less zinc blende.

Khvartz-khana, near Artvin, had a mining and smelting works, ready before the war, but never operated, belonging to the Siemens family and capable of yielding 2000 tons of copper a year. In the same region an American company possesses a mining and smelting works at Dzanzul, which produced 3,030 tons of copper in 1912 and 4000 tons in 1914, i. e., one third of the whole Caucasus output, and one tenth of that of Russia.

Karabagh Zone.—At Migri, the copper is found associated with molybdenite and iron pyrite in granulites.

The same group of Copper-Molybdenite exists at Hedgenan. The rest of the mineralization is formed especially of copper, in the southeast part of western Karabagh, in Pyrdandi, Okchai, Katar, Barabatoun, Shikhaus, Gavart, Astamal, Jivanik, etc. In different points these chalcopyrite are auriferous and associted with galena and blendes.

On the flank of Sahend copper, lead, antimony and arsenic are found associated with each other.

The oldest rocks of Jurassic age of Caucasian chain are believed to contain the most important metalliferous deposits.

The three copper producing centres of the region are Kedabag, 26.5 miles from Daliar Station, on the Tiflis-Baku railroad, Allah-Verdi, on the railway from Tifiis to Alexandropol; and thirdly, the Elvach or Zangezur district, 130 miles from Elvach, on the first named railway.

Kedabag.—This is the largest producing centre of the Transcaucasia, and has the largest smelting plant. It lies 26.5 miles from, and 450 ft. above Dalliar, the nearest railroad station on the Baku line. The deposits are found in the side of Copper Mountain Mio-Dagh, 5922 ft. high, occurring as lenticular masses found in a belt of quartz-porphyry 3500 ft. long and 1700 ft. wide, with diorite to the south and diabase porphyry on the west.

The later rock occurs in dikes cutting the quartz-porphyry, and also as a mass partly covering the ore-bearing rock and form-

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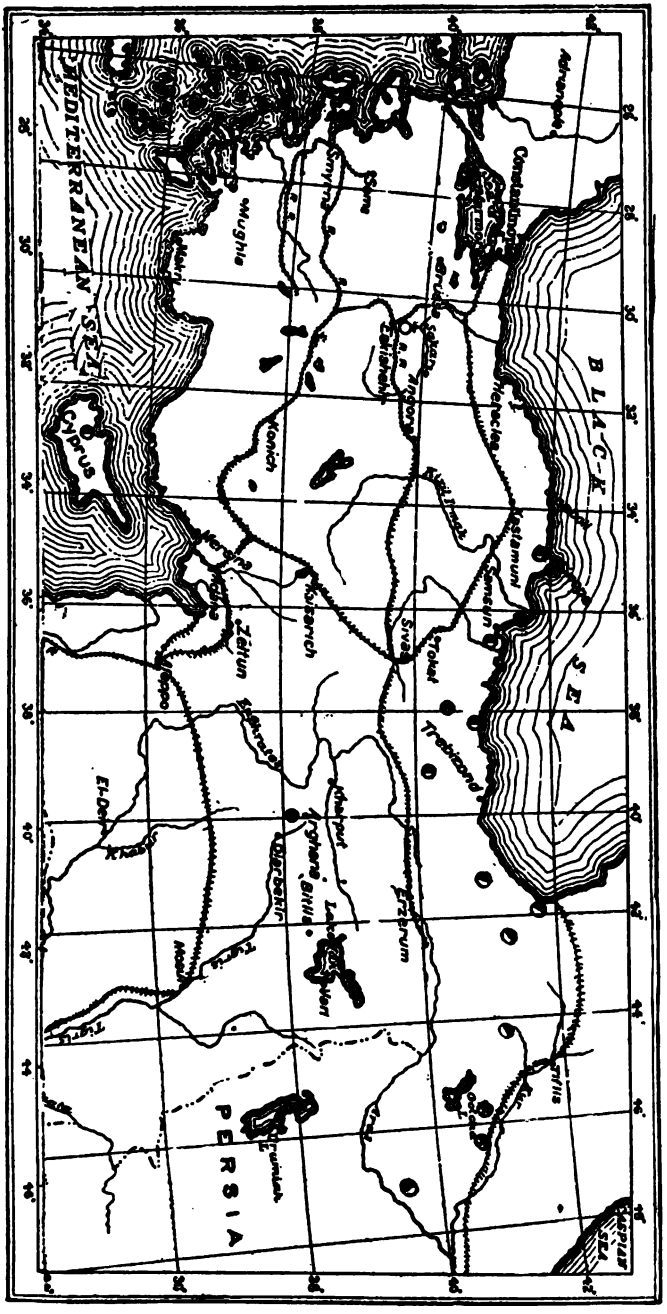

MAP REPRESENTS MOST IMPORTANT COPPER DEPOSITS OF ARMENIA.

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ing the mountain summit. A peculiar plagioclase-pyroxene-garnet rock, called "Kedabegite" is the youngest rock of the district, and is always near the ores.

The ore bodies are lenticular in shape; 16 of them are known, varying in size from 33 ft to 820 ft. in length, 16.5 ft. to 165 ft. in width, and 6.5 ft. to 165 ft. in thickness. These lenses do not outcrop, but occur 120 ft. to 420 ft. below the surface.

The ore consists of pyrite and pyrrhotite carrying chalcopyrite and some covellite, and rarely copper glance. The ore shows gradual transitions to the country rock, and the lenses sometimes consist of rock seamed by veinlets of pyrites ore. There are, however, no true fahlbands.

The richer ore is found against the hanging wall and fades out toward the foot into barren material. The richer copper ores invariably occur with zinc-blende, and carry considerable barite and quartz. Galena and magnetite are rare constituents of the ore.

The ores vary from 3 to 5 per cent. copper, with .005 to .008 per cent. precious metals, of which .4 is gold. These metals occur in the Chalcopyrite. The 7 per cent. or better ore is smelted in the reverberatory furnaces, using petroleum as fuel, to a 23 to 30 per cent. matter, which is re-treated in blast furnaces to an 88 88 to 90 per cent. blister copper that carries 2 lb. silver and 0.5 oz. gold per ton. The low grade ore is leached and in part sold for acid manufacturers.

The Galizuski mine is at Elizabethpol. It produced 1,390,095 lbs.. in 1899.

The Dzansulkli mine in Tiflis (Kutais) has recently been acquired by the Caucasus Copper Company, an English concern. The deposit is a lens 260 to 500 ft. wide, 100 ft. long, and opened for 164 ft. in depth. It consists of pyrite carrying Chalcopyrite, with a quartz gangue, and averages 3 per cent. copper with no precious metals. The output for 1889 was 505,568 lbs. This is too silicious to smelt, as fluxes are expensive. It will be concentrated by magnetic separators, experience showing excessive slimes and losses with wet concentration. A 100-ton plant is planned.

Elvach District.—The Sunik mines are the largest of the district and one of the three largest producers of the transcaucasian region. They are located near the Persian frontier, 130 miles

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from Elvach, the nearest station on the Transcaucasian railway line. The ores occur in quartz veins carrying chalcopyrite associated with bornite, tetrahedrite,pyrite, and rarely native copper. Small values in gold and silver occur.

There are 20 veins varying from 7 inches to 4 feet in width and clustered, in a range running northwest and southeast, through dark green andesite and black diabase. Fault fissures cut the veins and country rock.

The old workings are primitive, narrow adits running 100 to 300 feet into the hillside, and both ore and water were carried in leather bags.

The copper ores occur in quartz veins. The ore consists of chalcopyrite, and bornite, tetrahedrite and pyrite, with accessory blende and galena, the usual oxide ores and native copper being present. Old shafts 130 feet deep attest the energy of the ancient miners, when ores below 15 per cent. were not workable.

The ore occurs in northwest and southeast quartz veins cutting andesite, and in crush zones or breccias between syenites and diorites, the ores carrying copper glance, galena, and sphalerite. The veins have a proved length of 700 feet in depth. The output for 1900 was 800 tons of copper. Only 7 per cent. ore or better is treated, and this is smelted at Sounthsy for 5.8 dollars a ton. Mining costs 8.08 dollars per ton.

The Allah-Verdi district lies in a very mountaineous tract about 50 miles south of Tiflis. The ores occur in pockets in fractured dacite and quartz andesite. It is pyritic and treated by modified pyrite smelting. There are three deposits, Akhtala, Allah-Verdi, and Chambuk. An enrichment near gypsum masses is noted. Galena rich in gold and silver occur near the uppermost part of the first-named deposits. The mines, though ancient, have but recently reopened.

In 1902 the Transcaucasia produced 106,718 tons or ore, yielding 3438 tons of copper.

Arganeh-Maden.—An important copper mine is found in the Taurus mountains at Arganeh, (district of Diarbekr). Arganeh, lies about halfway between Kharput and Diarbekr. The space comprised between Kharput which measures about 50 miles from the mines presents a series of limestone and marly slates belonging to Cretaceous period. The higher portion generally consists

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of calcareous strata abounding in Nummulites, while the marls, which for the most part occupy a lower position are highly metamorphic, being changed in color and frequently hardened to the consistency of siliceous slate. Below both although sometimes occurring in dikes high as the mountain sides, appear rocks of diallage and actinolite in great variety. To the west of Kharput the mountains exhibit a different character. Their chief mass is composed of limestones and slates of an older period. The eruptive rocks occurring in juxtaposition with these are syenites, diallage rocks, basalt, similar to that of the plateau of Diarbekr. The city of Diarbekr is but on an extensive plain covered with

MINING DISTRICT OF ARGANEH-MADEN.

1. Dialage rocks.
2. Sulphuret of iron and copper.
3. Limestone.
4. Metamorphic slates.

rough fragments of basalt, resting upon more compact masses of the same rock. On the southwest this igneous formation extends beyond the town of Severek, a distance of 60 miles from the Tigris and in approaching the mountains to the northwest we find the same series continued for 20 miles. At Arganeh the southern outposts of the Taurus present their most remarkable feature. The serpentine is laid at base of Arganeh Maden, in the valley of the Tigris, and in the ravine formed by a rivulet which pours in its tribute close below the town. The rocks are generally full of leakage, and contain the magnesian minerals also. The breccia appears to constitute the outer wall of the cupriferous mass at Arganeh Maden. This mass though it continues in depth to the level of waters of Tigris, has not hitherto been opened anywhere except on the surface of the mountain above the town. It appears to be but one large lump of ore consisting of double sulphurets

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of copper and iron, planted amid these serpentines or perhaps between them and the marls. In the mines not the slightest character of a vein or bed was to be seen, but floor and walls consisted entirely of solid pyrite, diversified only by stalactite cuttings of blue and green vitriol. This extended to a depth of 60-70 feet but in addition 20-30 feet which had been excavated were filled with water. The shafts are scatteded irregularly over a part of the mountain which is almost level and is about 300 feet in dia-meter and since in all of these shafts the same appearance are presented, we may be justified in considering the ore as forming rather an isolated mass than as belonging either to a bed or lode. The pyrite varies so much in quantity that a large proportion is left untouched by the miners, not repaying them for working. In general, the ore contains from 10-20 per cent. of copper, while the better sort rises 20-20 per cent., and occasionally a little vitreous copper on pure sulphuret occurs, when the percentage is much higher.

From all accounts very high-grade ore is mined at this point within an area of 12 km. square. The deposit is known to have been exploited since the year 1096 A. D. During recent years, operations have been carried on intermittently by the Government, both on a leasing system and by direct management. In 1874 this mine was reopened under the direction of Austrian engineers and in 1896 under the Italian egineers, but closed on account of no capital. Cuinet gives the following analysis of this ore. Cu 30%, Fe 40%, S 30%. Weed states that the ore is high-grade, carrying from 10 to 12% Cu. Mining is conducted in the most primitive fashion. The ore is broken to nut size, conical heaps of the broken material are built up and covered with wood to which fire is set. This roasting lasts three days, and is succeeded by a similar operation on the product of the first roast. The resulting matter, containing 25 to 30 copper, is smelted in closed kilns from which the "black copper," as it is known to the trade, is finally derived. All of this black copper is transported on camel-back to Tokat, where it is refined and subsequently shipped to the sea-port of Alexandretta. The cost of mining and smelting is estimated at less than 3c. per pound, this being the price paid by the Government, which so far, has reseved for itself the sole right of purchasing the mattes. Transportation from Tokat to

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Alexandretta costs 2c. per pound.

According to recent researches of Germans, the ore does not go very deep, and that the extent of principal bed is equivalent to 1.7 to 2 million tons.

Some old copper mines at Tilek on the south and west extension of the Dujik mountain in Dersim are of special interest because of association of tin with the rich copper ore.

ANNUAL PRODUCTION.

Years	Metric Tons.
1897	326
1900	2341
1901	1665
1902	1118
1903	1422
1904	965
1905	711
1906	432

IRON.

There are extensive deposits of iron ores in Anatolia and Armenia, but the old iron industry is entrely dead, and the European companies did not invest the capital necessary to build blast furnaces.

Toward the east of Trebizond, along the axis of diorite, outcrops a bed of iron ores, in the valley of Kalo-potamos at Demirdagh. This deposit which has relation to green rocks, is especially noted in reason of historical traditions calling this region of Khalybs as the cradle of the metallurgy of iron.

The Damir-Tash on the left bank of the Bolnis River (Somketian) shows the intersection of two N. N.—S. S. E. W. trending systems of hematite wth 23-60 per cent. iron, in Turonian limestone.

Similar conditions obtained at Sizimadeni on the southern extension of the same N. N. W.—S. S. E. line. The hematite was extensively mined.

Still further south in the Dybakli pass between Varatal and

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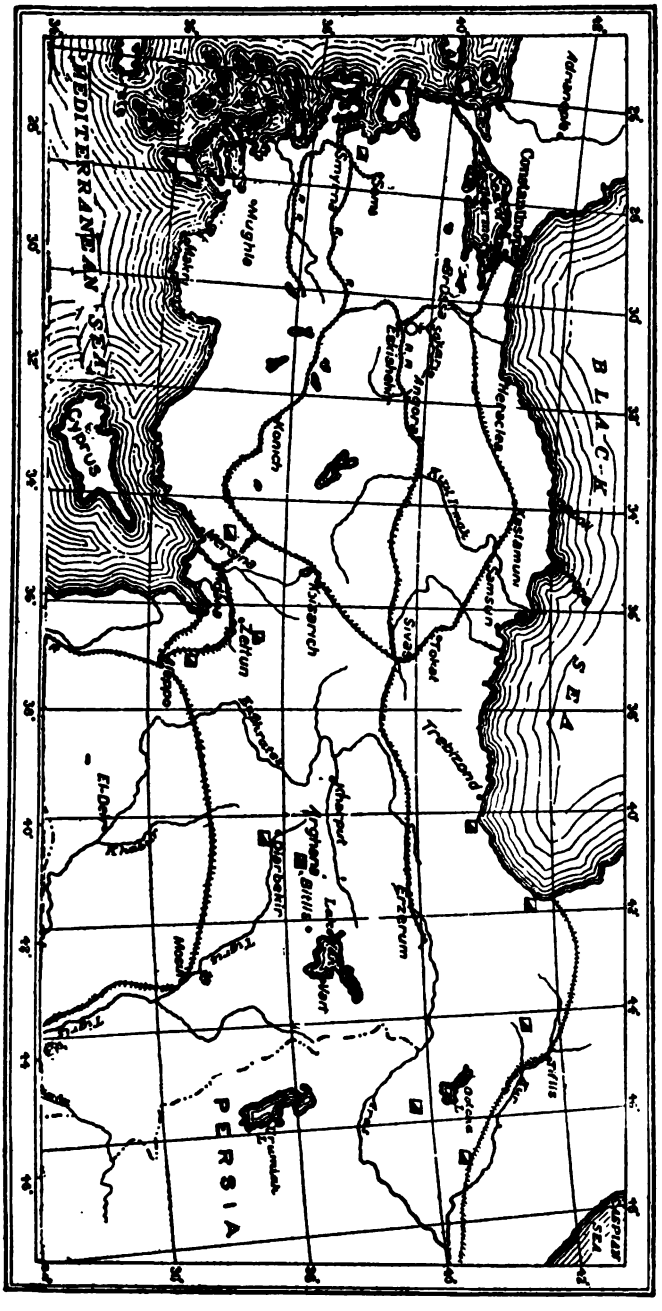

MAP REPRESENTS THE KNOWN IRON DEPOSITS OF ARMENIA AND ANATOLIA.

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Miskhan on the south side of the Pambak chain appear hematite veins and nests in the chloritized contact zone in pyroxene porphyry.

A thin spreading scale magnetite mass exists in an augite epidote garnet rock at Dashkessen, in the Gokcha chain.

A very pure hematite has been obtained from the nearby Bozantel.

At Chinarli, not far from Elizabethpol the iron is 2.2 meters thick and affords up to 65 per cent. iron.

Considerable beds of limonite and magnetite exist on Kishala plateau (east Karabagh.)

Iron glance is obtained in the Talori mines in Taurus.

In the vicinity of Diabekir, in the valley of Tigris River, sands of magnetite are existing. These mechanical preparations executed on volcanic rocks where the tenor of iron oxide is very notable as existing in different localities of Armenia playing a great rôle in primitive metallurgy.

Cilicia is an important district containing the richest ore bodies of iron and well known for its old iron industry long time in the past. The chief mines are situated in the Bulgar-Dagh, Bierout-Dagh (Zeitun), in the vicinity of Aleppo and Belen. All these mines occur in the limestone in contact with serpentine rocks.

In Bulgar-dagh, in Cilician Taurus veins of limonite occur in limestone (see description of Bulgar-Maden). In the same range, at different points, there are extensive beds of limonite and hematite. Some of them have been mined at different times. There were formerly furnaces in this region.

On the slopes of Beirout-Dagh, 15 miles from Zeitun to northeast, at the foot of eastern slope of Anti-Tuarus, exists an extensive deposit of high-grade hematite. This is known to the blacksmiths throughout the Syria and Mesopotamia as obtaining their iron from the natives working these deposits.

The natives have been smelting the iron ore in an imaginarily built blast furnace, using the woods cut from neighboring forests as fuel, and the blast was supplied by a large pair of bellows operated by two especially trained bears.

This working was abandoned 25 years ago, on account of political troubles. This is one of the least visited locations by foreign engineers and research men, on account of its inaccess-

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ible location and unfavorable political conditions.

Continuing the chains of Anti-Taurus we find an abundant deposit of hematite in the veins of the mica schists and argillaceous rocks with calcareous intercalations on the side of Kozandagh. This region has also been very difficult to approach on account of unfavorable political conditions.

Tchihatcheff has shown long ago the existence of carboniferous coal beds either in the vicinity of Zeitun iron mine or Kozandagh.

Iron mines are also worked in the vicinity of Aleppo.

In eastern Asia Minor iron ores have been discovered at Vierla and Bazar-Koi.

Magnetic iron beds are surveyed by Germans during war, at Ayasmund north of Smyrna; many other occurrences, specially the red iron stone passing into emery are found in this neighhood.

CHROME.

Asia Minor has been for many years the most important producer of chromite in the world. At least 120 places have been named where chrome occurs; these are mostly in the province of Broussa, Aiden, Konia, Angora, Adana, Aleppo, Diarkebir, etc. The most important mines being in Broussa in Makri, province of Hudavendighar, and in Antioch near Aleppo and Iskenderoun.

The chrome was discovered first by Pro. J. L. Smith in 1848 at Broussa, city situated on the south east of Constatinople at 57 miles distance. It occurs here, as elswhere, exclusively in the serpentine in the shape of pockets and veins of irregular extent and size. The mine of this district was practically a monoply in the hands of Messrs. Patterson. Another large deposit, also discovered by the same man, exists at Harmanjik, about 15 miles south of Broussa, under same conditions of occurrences as above.

The Chrome ore of Asia Minor having a very low silica content and being very soft have been in great demand, and for many years have constituted the principal source of supply of both American and European consumers.

Mr. Show contributes the following analysis of these ores:

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		Per Cent.	
Sesquioxide of chrome	55.04	51.70	56.80
Protoxide of iron	12.63	14.20	12.06
Alumina	11.84	14.10	14.00
Magnesia	16.19	14.30	15.00
Silica	2.00	3.50	1.45
Lime	1.40	1.70	0.70
Water	.40	.30	0.15
Total	98.86	99.80	100.16

The Vilayet of Aidin is a province in Asia Minor which has a coast line extending from opposite the island of Mytiline to beyond Makri, opposite the island of Rhodes, and embraces almost the entire basins of the two principal rivers, the Sarabat (Hermas) and the Meander (Mendereh), besides some smaller ones. The principal town is Smyrna, the center of trade of the district, from which two railways run into the interior along the valleys of the two rivers just mentioned.

The greater part of this country is composed of limestone, sand, schists, and presents a fine example of orthodox regional metamorphism. The shell, mud and other beds, originally deposited over a sea bottom, extending probably far beyond the region here described, have been completely metamorphosed, the limestone of pure white saccharoid marble, now covering large areas, and the other bed interstratified with it, to schists of various kinds—mica, chlorite and hydromica, often changing gradually the one into other and sometimes passing insensibly into gneiss. In several localities the schist contain regular octahedra of magnetite up to half an inch in diameter.

The general strike of these formations throughout the country is about east and west, though locally the schists are much folded, and strike and dip in all directions. The average dip is steep but not uniform, and is not always apparent. South of Aidin it appears to be to the north. Further north again, at Odemish, the dip is south, indicating several parallel foldings of strata, the number and extent of which observations were not sufficient to determine.

In several places serpentine belts occur. These appear to be

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interstratified with the marbles and schists, and would thus point to a result of general metamorphism on original possibly glauconitic deposits; but further investigation is necessary before it can be definitely asserted that they are not alteration products of intrusive sheets of basic olivine rocks. Around the bay of Smyrna extensive areas consist of volcanic lavas and tuffs, chiefly trachyte. Overlying the metamorphosed formations there are found in places such as between Suladan and Ala-Shehr, and south of Cheshmé on the coast, undisturbed beds of sandstone, lying flat or dipping at a very slight angle, and full of fossil shells, chiefly gasteropods.

The most important chromite occurrence at present are at Makri, opposite the island of Rhodes, at Daghardi south and southwest of Olymph, and at Kemikli.

The chrome ore in the province of Aidin was also found by Dr. J. L. Smith. It occurs in the serpentine in pockets and in veins of irregular extent. Messrs. Patterson owns the mines all in the neighborhood of Makri.

The value of ore depends on its contents of sesquioxide of chromium. Shipments have been made from Makri containing as much as 58 per cent. The lowest content marketable is 47 per cent., and this only if the ore is soft and easily crushed. Such ores have been preferred to the very hard ore, which latter must contain at least 50 per cent. to be marketable.

It is a curious fact that Patterson states, that the best ore is gotten near the surface, and that in depth it invariably becomes poorer.

Chrome ore mines in the east of Amanur, near sea-port of Mersina, running 51 to 53 per cent. chromic oxide. The production for the year 1911 was 2000 tons, all being exported to Germany and France.

ANNUAL PRODUCTION OF CHROME.

Years	Metric Tons.
1892	13,780
1893]	
1894]	20,250

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1895 1896	21,030
1897	20,137
1899	4,538
1900	9,749
1901	40,972

MANGANESE.

Manganese ores occur abundantly in Asia Minor and Armenia. The most extensive beds are found in transcaucasian provinces. These last deposits have more or less been exploited and good deal of development work has been done so far.

Transcaucasian Manganese.—Manganese ores are known to exist in Caucasian Armenia in a number of localities, viz.: in the government of Kutais, near the village of Chiaturi, in the same government near the Chorokh river, southward from Batum; and in the governments of Erivan and Tiflis. In smaller quantities they are found in various other places also. The first mentioned deposits are by far the most important. All the manganese ore now known in the market as "Caucasian" ore comes from Chiaturi; no other deposits in the Caucasus having been worked commercially; movements have been made, however, towards the exploitation of some of those on the Chorokh River.

No other known deposit of managanese ore can approach that of Chiaturi in capacity for producing large quantities of high-grade ore at a low cost. The deposit is said to have been discovered in 1848, by the geologist Abich, but the first shipments were not made until 1879, when 870 tons were produced. Since that time, the production has steadily increased, until now the world relies on this deposit for about one half its supply of manganese ore. The total production of the mines of the Chiaturi arrived to 1,682,400 tons in 1898.

Chiaturi is a village of the district of Sharopan, which forms part of the Transcaucasian province of Kutais. The village lies on the Kvrilli river, a tributary of Rion, which enters the Black Sea, near Poti, and is now connected by a narrow gauge railway with the station Sharopan, 25 miles to southwest, on the main line of the Transcaucasian railway.

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The vicinity is characterized by high, and in some instances precipitous, mountain spurs left by the erosion of the valley of Kvrilli river, and of the ravines through which flow its tributary rivulets.

The ores of Chiaturi occur in a bedded deposit, lying almost horizontally, near the tops of the lofty hills in the vicinity of the village and at an altitude of 1000 feet above the Kvrilli river. The action of the elements in forming the rugged topography observed in this region has carried away, perhaps, more than one half the original deposit.

The existing bed has been opened on seven of the mountains near Chiaturi. Of these three designated locally as Perivissi, Chocrotti and Itvissi respectively lie to the south of the Kvrilli river, and four—Organyi, Zedorganyi, Givimavi and Darkvetti, —lie on the south side of the river.

The bed occurs in a brown sandstone of Miocene age, and has an average thickness of between 6 and 7 feet. Its dip, which is slight, and fairly regular, is southerly, slight faulting of the formation has occurred in some instances; but few folds are observed and the bed is free from sudden or extreme variations from the average thickness.

The deposit has a distinctly stratified structure and is composed largely of pyrolusite, but other oxides of manganese also occur. In many instances, strata of sandstone, or of loose, friable arenaceous and calcareous material, are intercalated with the manganese ore, such strata vary in thickness from a small fraction of an inch to as much (in some of the intercalated layers of sandstone) as 10 inches, or a foot.

The area given by government engineers is about 60 sq. miles embracing the whole bed known at present time.

It is quite certain, however, that an area of more than 22 square miles of the present surface is underlain by ore available for mining; and on this basis it is estimated that, even if the crude and wasteful methods now pursued should be always continued, the bed will yield more than 80,000,000 tons of marketable ore. The deposit is intercalated between two beds of limestone of Eocene age, and is associated with layers of sand, the ore occurring either as an oolitic stratum or as lumps disseminated in beds of clay, the minerals being chiefly pyrolusite and manganite.

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A complete analysis of very well sorted and cleaned ore from Chiaturi, gives the following results:—ore dred at 212° F.

Manganese peroxide	86.25%
Manganese protoxide	0.47%
Iron peroxide	0.61%
Oxide of copper	0.01%
Oxide of nickel	0.30%
Alumina	1.74%
Lime	1.73%
Magnesia	0.20%
Baryta	1.54%
Potash & Soda	0.22%
Silica	3.85%
Carbonic Acid	0.63%
Sulphur	0.23%
Phosphoric Acid (0.141 P)	0.323
	99.953

The occurrence of baryta with manganese shows the destruction of neighboring crystalline rocks, rich in manganese, through weathering. In course of recent geological periods and immense quantity of manganese have been carried by rivers to the sea. Manganese so brought to the sea has been precipitated, probably, by slow oxidation due to oxygen dissolved in the water, through an absorption by descending volcanic ash, bone fragments may also have been operative.

This deposit of manganese formed by sedimentation may be regarded as a shallow water deposit containing shark's teeth. From the tetonics in the place it is evident that the deposition of manganese has taken place in shallow water, probably in large lagoons and in a shallow sea fairly near the coast.

At Kutais gneiss or granite occurs at some distance from the manganese deposit. The solutions must be derived this crystalline rocks.

It must be pointed out that the manganese beds as well as lodes are not particularly associated with basic rocks, the majority occurring in genetic relation with acid rocks such as gneiss, granite, quartz porphyry, etc. The solutions from acid rocks

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probably therefore originally carried as a rule more manganese than similar solutions from basic rocks.

Manganese elsewhere in Caucasus is found also in veins, often in pockets or masses and frequently are mixed with the gangue. Pyrolusite of this structure is specially found in Pontic region, in Archava, Riseh, and Surmeneh districts. The amount is too small to make mining feasible.

The district of Phlinika in Asia Minor occupy an important position in the production of manganese in form of pyrolusite, containing 52 per cent. manganese in the ore.

A small amount of manganese is also mined at the Zengan with average assays showing 83 per cent. managanese dioxide.

Manganese mines are also worked in the province of Trebizond, on Black Sea coast.

Occurrences of the manganese ores are, moreover, known in the vicinity of the seaport of Mondania, as well as near Seshkeni, Balia, and Ushak, all in Anatolia.

Internationally most important beds of manganese are found at Eregli on Black Sea coast.

ANNUAL PRODUCTION OF MANGANESE.

Years	Metric Tons.
1888	669
1889	8000
1892	2900
1893	2225
1894	8400
1895 1896	33500
1897	49000
1898	55300
1899	49468
1900	38100
1903	39500
1911	18000

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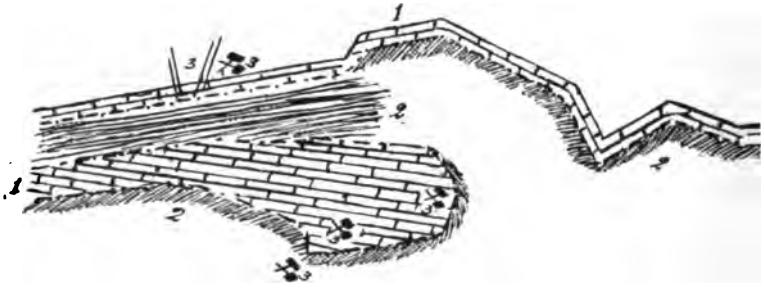
MERCURY.

Two deposits of Cinnabar are known at present in Anatolia; one in the province of Konieh and the other in the district of Smyrna.

About 400 miles by rail southeast of Constantinople, in the department of Konieh, near the old city of Iconium, now known as Konieh. The Konieh Mercury Syndicate, Ltd., was opened in 1905 to operate a cinnabar deposit of considerable promise.

The cinnabar occurs in veinlets, nodules and small particles in a crystalline limestone close to the talcose-schist contact at no great distance from the old eruptives. The occurrence of the minerals is not uniform throughout the limestone; it appears to be present only where, or near where, the limestone is much silicified, or entirely replaced by quartz suggesting that the



GEOLOGICAL POSITION OF KONIA MERCURY MINE.

1. Limestones.
2. Slates.
3. Ores.

quartz and mercury had a common origin or were deposited at about the same time.

While there are a few nodules and rich veinlets of several inches in width, the greater part of the workable deposits consist of the siliceous limestones seamed and veined with the little stringers of the sulphide, the whole assaying from 1 to 2.5 per cent. mercury. One considerable body was found associated with stibnite; this carried about 8 per cent. of mercury.

Quartz croppings and float occur at numerous points that where work is now being prosecuted. All of these quartz contain visible

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cinnabar, but little of a grade to be treated profitably. Scattered over a considerable area, however, it suggested that where the quartz penetrates the limestone other workable deposits would be found. Subsequent developments have proved this to be the case.

This property is probably one of the earliest mercury mines to have been worked, though the date of its early operations is not exactly known. In this connection its rediscovery and opening are interesting.

About 1901, four years before the operation of the mine, a goatherder who kept his flocks on the almost baren hills near Konieh corralled them at night in a limestone cave within a short distance of the buried cities of the Holy Land. Night after night they were taken there for protection. One night a refractory goat refused to enter the portal, and the goatherder picking up a stone to discipline the offending animal, noticed that it was heavy and dark red in color, different from other stones around there. Laying it aside, he one day broke it open between two large stones and saw that it was a beautiful rose color on the inside. With curiosity aroused he went to an arroya below the cave to look for similar stones; he found one more but that was all.

After this next clip was made, he went on his annual trip to Konieh to dispose of it, taking these two peculiar stones with him. The wool and stones fell into the hands of a local merchant acting for the Whittall Bros., exporters of Constantinople, and he too, thinking the stones were curious, sent them on to the seaport, to his principals when making a shipment of wool.

One of the Messrs. Whittal was a graduate of Royal School of Mines, and as soon the stones fell into his hands he recognized them as high-grade cinnabar, knowing that mercury had been found at several points in Asia Minor, Hugh Whittall, the engineer, decided that when convenient, he would visit that locality. In the course of time he made the trip, with the assistance of local agent in Konieh, the goatherder was found, also the cave where the goats were kept and the ravine below it, but nothing that in any way resembled cinnabar.

The cave had the appearance of any limestone cave with sides worn smooth and the bottom covered with the dirt of centuries.

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The search for cinnabar was about given up when Mr. Whittall began to disfigure one of the walls with his sample pick. An incrustation was broken off and a tiny veinlet of something pink was seen; picking through the incrustation in various places, the same conditions were found to exist in several places. In short, the whole bed of limestone appeared to be impregnated with small seams and veinlets of cinnabar, and what had appeared to be an ordinary limestone cave resolved itself into something looking like an old mine. The property was denounced for mining purposes and instructions given for cleaning the dirt.

When the work was started, in 1905, the opening was about 15 ft. wide and it extended 50 ft. into the hill, with the roof about 10 feet above the floor. When completely cleaned out it was found to extend a little more than 100 ft. dipping with the limestone beds at an angle of about 10 degress from the horizontal, everywhere that the silicfied limestone appeared thereto was cinnabar found. When the cleaning had been done it was decided to put down a winze in the floor of the deposit to see what thickness the impregnated beds might have. The winze was started at 6 ft. it broke into several chambers almost under the first, parallel with it and of about the same dimensions except that it was nearly 250 ft. long.

It was a surprise to find that the first cave was a mine, a greater surprise was in store in the second cave. Entering through the opening in the bottom of the winze a wierd sight met the eyes of the miners. Scattered over the floor of the chamber, in all conceivable positions, were seen the remains of more than 50 human skeltons. Many of the bones were imbedded in the secondary deposits of limestone on the floor. There were great quantities of stone, hammers, several pottery lamps, a fair amount of charcoal, several rubbing stones and some flint arrow heads.

Mining had apparently been done by firing the barren rock, by breaking the softer portions with hammers and by gouging where there rich seams of cinnabar. Deep groovers followed all high-grade streaks, but the tool for this work were gone.

Working out to the surface, following the floor of the second chamber, 40 to 50 ft. of caved ground was pentrated, suggesting

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that the miners had been entombed by a fall of rock around the portal of the opening.

Sometime before this discovery Sir W. Ramsey, the well known English Archiologist, had unearthed a tablet in a neighboring buried city. This tablet was dedicated to the Phrygian goddess of the mines, Zizima. The Phrygians inhabited this part of Asia Minor 1500 years B. C. and it is quite possible that the deposit was worked as long as 3000 years ago.

There is no positive evidence connecting the tablet with the mercury deposit, but on the other hand, nothing else has been found resembling a mine. The thick deposit of lime, on the floor and walls of the openings in such an arid country as this is positive proof that the bones were lying there a very long time, and the probability is that the deposit was a flourishing paint mine many centuries before the birth of Christ.

Up to the middle of the year 1905 about 15,000 tons of one per cent. mercury had been opened up.

KARABOURNOU MINE: Karabournou mines are situated about 30 km. from the town of Smyrna. The deposit lies in the vicinity of basaltic flows, and consists of metamorphic siliceous schist impregnated with cinnabar. Mining is done entirely in open cuts on ores containing as little as 0.25 per cent. mercury. When sorted the cinnabar appears to concentrate in the fine, and the ore is accordingly screened. The concentrate assays from 0.75 to 2 per cent. mercury.

The plant at the mine comprises two double Spirek towers, furnaces for broken ore, and a Cermak-Spirek furnace for fine.

This installation has a capacity of 30 tons per day. This mine produces about 3000 flasks annually. The smelting plant at this mine includes one Spirek tower of 15 tons daily capacity and one Cermak-Spirek furnace of 8 tons capacity per day.

Mine is found at an altitude of 1800 meters. Operation is somewhat hindered by the severe winters at this elevation.

ANNUAL PRODUCTION OF MERCURY.

Years	Metric Tons	Value
1908	98.5	14175
1909	142.0	22000
1911	450 flasks	

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ANTIMONY.

Antimony is a well known mineral in Anatolia. It is found in irregular veins (as it is the case for all beds of primary grounds) and inter-stratified in the schists, specially in veinlets of different sizes. The age of the deposits generally not known. The formation is always irreguiar. The stibnite is onlp accompanied with quartz and pyrite. But it must geographically be attached to the beds of cinnabar.

The stibnite occurs in the valleys of Broussa, Smyrna and Sivas.

The two important centers of production in the province of Smyrna are Eudemish andDjinli-Kaya, in both of which high-grade ore is found, often carrying 65 per cent. antimony.

A double lode, the outcrop of which may be followed for 2 km. is worked in Djinli-Kaya mine 20 km. southwest of Eudemish and 100 km. east southeast of Smyrna, on the northwest slopes of the Baliamaboli-dagh. The width of the deposit varies from a few centimeters to some meters. In 1898, 500 tons of ore valued at about 6000 pounds were won.

In the same Vilayet the mines near Rosdan and Aidin city and finally the Gerasmos and Kordelio mines also occur.

All these are stibnite veins containing more or less pyrite and are imbedded in the metamorphic argillaceous schists, mica schists or gneiss.

Antimony in Broussa is represented by lodes 0.1 to 2.0 meters wide, worked in a mine known as the Gometschiftlik-Antimon maden, belonging to the Sultan, situated 24 km. east of Gedis, on the south western slope of the Kizil-dagh. The yearly production is about 500 tons of antimony. Here veinfilling in the amphibolic gneiss pass in cipolin. The veins are very irregular changing continually in thickness and length. They are often not longer than tenth of a meter, and are not wider than 2 meters as maximum. This mine is exploited in open cut.

Half a Km. south of Demir-Kapu there are other antimony mines. At Irvindi and Suluk-Koi. Here veinlets of quartz with stibnite is intercalated in the argillaceous schists 2 meters long and some centimeters wide.

In the Vilayet of Sivas antimony ore has been opened up at

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Kara-hissar. Here the antimony ore occurred in pure igneous rocks free of quartz.

In all these occurrences the antimony forms irregular veins, as it is the case in all primary deposits and tend to inter-tratify in the schists. The minerals are put usually accompanied with the quartz and pyrite. The association of mercury with antimony is a particularly interesting case in Tertiary formations, where antimony looks entirely different in these conditions than in the ancient chains, being associated with metallic sulphur, among which the cinnabar has different sizes of vein fillings.

ANNUAL PRODUCTION OF ANTIMONY.

Years	Metric Tons.
1892 1893	1035
1893 1894	1545
1895	1332
1896	100
1897	400
1899	1173
1900	267
1901	224
1902	481
1903	298
1905	188
1906	1035

LEAD.

The chief lead mines occur in the provinces of Trebizond, Diarbekr, Hudavendighar, Adana and Erzerum. The lead is found mostly associated with silver and sometimes with zinc.

Lead mines near Van, in several adjoining districts, are discovered. Near Gulek lead mines were formerly worked and smelted. The deposits occur as lenticular masses in Cretaceous limestones, with flint passing into mica-slate. The ores include galenite, sphalerite and arsenopyrite.

The only lead mines in operation in Anatolia are those at Li-

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jessi, near Karahissar and at Gamlibel, near Enderes, both of which are operated by Asia Minor Company.

In Sivas, the lead ores occur associated with antimony. Two of the mines were worked by a British company.

The most important beds of lead associated with silver occur in Balia, Boulgar-Dagh, and Keban.

Balia-Maden.—The lead-silver is here deposited in the Tertiary augite-andesite rock in contact with metamorphosed limestones. Metallic sulphur and silica are developed in the contact of igneous rocks with limestone, in a zone from 2 to 5 meters large. A very small proportion of silicate replaced bp calcareous rock shows the order of consolidation; epidolite, garnet, with pyrite and anorthosite with galena. Here sometimes a pocket of very hard and compact galena is found embedded in the andesite, 26 meters long, from 3 to 5 meters wide, and 6 meters deep. The ores carry galena, blende and pyrite, containing on an average from 16 to 20 per cent. lead and 8 per cent. zinc.

Boulgar-Maden.—The mine is found in a valley on the main route opened from Chifté Han. The metalliferous formation extends about 100 km. up to calcareous rock in contact with Eocene schists. The schists are traversed by serpentine with which the minerals have relation in origin. Beyond the contact of calcareous rocks with schists there is a contact zone of calcareous rocks with microgranulite. This is persued in all extensions in the metallic formations of Bulgar-Maden. Stone masses of ore are filled in the pockets of this microganulite. This bed is subjected to alterations below the level of the valley; which is due to subterranean circulating waters, in contact with metallic sulphurs. Ore is rich in lead, the medium tenor being 20 per cent.

Keban-Maden.—This is a complex deposit of argentiferous galena, blende and pyrite with antimony. Ore is formed in contact zone of limestones with porphyry, which is found more plentifully disseminated near the junction of two species of rocks; although some rich portions of nearly pure argentiferous sulphuret of lead here and there have the appearance of occurring in veins. One hundred pounds of excavated ore contains 1 to 1.5 ounces of silver.

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ANNUAL PRODUCTION OF LEAD.

Years	Metric Ton	Years	Metric Ton
1894	1,078	1907	10,398
1895		1908	11,772
1896	1,764	1909	12,128
1897	1,785	1910	12,700
1900	2,800	1911	13,000
1905	10,000	1912	12,500

ZINC.

From the amount of zinc production listed below, seems very probable that the exploitation of its resources has been lately undertaken and some development work has been done. The data concerning their geological features are lacking except the zinc deposits of Balia. Zinc is also extracted from silver and lead mines as it is already discussed under their respective headings.

A deposit of Calamine was worked at Karasu, close to the Zakaria river, in the province of Ismid. The mines were owned by a French company.

Other known deposits of zinc ore occur in the province of Adana which have not yet been developed.

A small amount of work has been done on a zinc mine at Bazar, in the district of Bigha.

Zinc has also been discovered at Kirasliyaila, in the vicinity of the ancient town of Pergamos.

Near Smyrna, zinc occurs with the lead, while at Karalar the ore is silver bearing.

Zinc associated with silver lead of Balia-Maden, is already discussed.

PRODUCTION OF ZINC.

Years	Metric Tons.
1892	100
1895	112
1896	
1897	1309
1898	18000
1911	40000

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TIN.

A Tertiary cassiterite tin ore is described in Kurbaba Mountain near Tillek (Armenia), and between Sahend and Araxes River associated with copper. But those ores have more historical and scientific interest rather than industrial importance.

Some kind of ore is described near Migri, (Caucasian Armenia) on Araxes associated with molybdenum and in Hejenan where molybdenum associated with pyrites and copper in granulites is found.

The ancient records show that tin, cassiterite ore, was mined near the present towns of Sinous, and also near Aleppo.

ARSENIC.

At Julfa, in Daridagh (Armenia), gypsum occurs in cracks. In these cracks of gypsum marl are found veins and nests of realgar and gold pigment.

Realgar is also found further north in Bechenak near sulphur mine.

At Bocha in the basin of the lower Charoth south of Batum gold pigment is found which is used by dyers of Artvin.

Valuable gold pigment mines lie at Andanise, between Bashkala and Kochanese in Taurus.

The mines, in the province of Aidin, in Anatolia, is large and rich deposit of Arsenic-pyrite in the vicinity of Eudemish and elsewhere.

The most important deposit worked is situated in the neighborhood of Yenikoi, where from 600-800 tons per annum are produced. This ore assays as high as 42 per cent. arsenic and carries considerable gold.

The mines at Elkhur, near Rozdan, produce 500 tons a year. The ore is found in the same veins that carry the stibnite, but in pockets free from the presence of this last named mineral.

ANNUAL PRODUCTION.

Years	Metric Tons.
1893	200
1894 1895	303

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COBALT.

A deposit of cobalt ore has been found at Dash-Kessan, in the government of Elizabethpol, which takes the form of a dyke impregnated by cobalt associated with iron and copper pyrites. This is important among all mines of cobalt. This cobalt ore is almost entirely free from nickel and consists of a thick bedded lode of magnetite.

The one at Chatakh consists of a large irregular mass of diorite impregnated with iron glance.

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